AFIT/GLM/LAL/99S-10

AN EX POST FACTO ANALYSIS OF E-3 MAINTENANCE INDICATORS IN THE 552D AIR CONTROL WING SINCE REORGANIZATION UNDER AN AIRCRAFT GENERATION SQUADRON CONCEPT

THESIS

Larry J. Stetz, Captain, USAF

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THESIS

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Preface

Seven years ago when I came on active duty, my first boss, Captain E. R. "E-Bob" Steen handed me a notice from an organization called "AFIT" that said I may be eligible for one of their Master's Degree programs. At that time, I had never even heard of AFIT. Little did I know that six years later I would be entering the AFIT program in-residence to complete my Logistics Management degree!

The thesis you are about to read is the culmination of a idea placed in my mind by a former AFIT graduate, Major Billy Gilliland, at my last base. The idea was to fully analyze the maintenance indicators in the 552d Air Control Wing to see what really "made them tick." This idea, of course, has been contemplated by more than a few maintenance officers in the past; however, the realities of running a flight line day to day quickly made them forget about attempting such an endeavor. The idea grew in my mind, and was shaped and refined over the months I spent here pursuing my degree. I hope it will give other maintenance officers the spark needed to pursue similar studies of their aircraft maintenance organizations.

As I leave AFIT to return to the "real" Air Force, I have two thoughts in my head about graduate education. The first came to me from my program manager and thesis advisor, Major Steve Swartz. He said, "In graduate school, the answer to any question is, 'It depends.'" The second came to me from my economics professor, Dr Leroy Gill. He said, "In good graduate schools, the answer to any question is, 'It depends—and here is what it depends on.'" (Ok, in all fairness, Major Swartz also said that you have to explain what it depends on—I just pretended that I didn't hear that part!) If you're trying

to decide whether reading this thesis is worthwhile, the answer is, "It depends. What are you hoping to learn by reading it?"

In closing, I want to take this opportunity to thank my thesis advisor, Major Steve Swartz, and my thesis reader, Dr. Freda Stohrer, for their invaluable assistance in completing this research. I would also like to thank AFIT's very own statistics wizard and virtual icon, Dr. Dan Reynolds, for his no-nonsense answers to my statistics questions, and for teaching me a thing or two about torturing numbers.

Finally, I would like to acknowledge and thank my lovely wife, the former Kendra Jones of Oklahoma City (Go Sooners!) for following me up here to Ohio as my girlfriend, but leaving here with me as my wife. Planning a wedding and completing AFIT at the same time were hard on us both. Guess what dear, we made it! I love you!

Larry J. Stetz

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Abstract

Organizational restructuring sometimes occurs in the aircraft maintenance field, yet seldom are in-depth analyses performed after the fact to see if productivity improved. In December 1995, the 552d Air Control Wing restructured its flight line maintenance into an aircraft generation squadron concept. This study looked at before and after maintenance indicators to see if productivity improved.

Maintenance data was collected from December 1993 to December 1997. Nineteen maintenance indicators were identified, and the key indicators were analyzed using means comparison and regression analysis to determine if efficiency and effectiveness had increased. The variables Mission Capable rate and Man-hours per Flying Hour were regressed to determine the prime determinants of these variables.

The results indicated that the aircraft generation squadron concept did not result in a more efficient or more effective flight line maintenance organization. Efficiency and effectiveness appear to have decreased under the aircraft generation squadron concept. The research did not determine if the old maintenance structure could have performed better than the aircraft generation squadron structure. The conclusion drawn was that the maintenance structure should be modified to increase productivity.

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I. Introduction

General Issue

When leaders formulate strategy for their organizations, they often look backward to see what has been done in the past. In recognizing the mistakes of the past, leaders hope to avoid those same mistakes in the future. It is an old maxim that in almost every field, change is inevitable. Mistakes, however, need not be.

In the fifty plus years that the U. S. Air Force has been in existence, the field of aircraft maintenance has seen its share of reorganizations. These reorganizations occur for various reasons: new or different perceived threats (adversaries), higher, lower or revised budgets, new senior leadership philosophies, and so on. When these reorganizations occur, it is only natural to ask, "Is this a change for the better, or for the worse?" While the motivation driving any reorganization is to make improvements, does the harsh reality of the real world bear that out? If, after careful analysis, the facts show that the organization is not better off—that there have not been gains in efficiency or in productivity, then the leadership should take action to correct the problem. The organization should also learn from that experience, and draw on it in the future when changing times demand another change in organizational structure.

This thesis analyzes a change in the maintenance structure of one specific Air Combat Command (ACC) flying wing, utilizing maintenance data and statistical analysis to determine if the new structure was an improvement over the old structure.

Background

In the summer of 1995, the senior leadership of the 552d Air Control Wing (552 ACW increased the number of combat ready E-3 Airborne Warning and Control System (AWACS) flying crews from 25 to 40 as a direct result of the accidental shoot down of a U.S. Army Blackhawk helicopter over northern Iraq in April 1994 during Operation PROVIDE COMFORT. Investigation into the shoot down revealed several findings, one of which established that the AWACS crew involved in the shoot down had not been adequately trained before deploying into the Area of Responsibility (AOR). Around the time of the shoot down, there were insufficient AWACS crews available to handle all of the worldwide commitments, so some crews were sent into the AOR with less than adequate amounts of training. Prior to the shoot down, the 552 ACW leadership felt the levels of air crew training were adequate. After the shoot down and subsequent investigation, the leadership decided to fix the problem by increasing the number of combat ready air crews, and by increasing training at home station through increased sortie levels.

The flight line maintenance structure in place at that time fell under the concept of operations held by ACC—the major command for the 552 ACW. Flight line maintenance personnel were assigned to one of four flying squadrons under the 552d Operations Group. Three flying squadrons were combat coded: the 963rd Airborne Air

Control Squadron (AACS), the 964th AACS, and the 965th AACS. The fourth flying squadron, the 966th AACS, was coded for training. Locally, the maintenance portion of each flying squadron was known as a "flying squadron maintenance unit," or FSMU.

After the 552 ACW commander announced changes in crew numbers and training sortie requirements, the senior maintenance leadership of the wing realized that a new maintenance structure was needed to meet these new sortie requirements. They sought and gained approval from ACC headquarters to implement an aircraft generation squadron concept and conduct a two-year test of its effectiveness.

The test began with the stand-up of the 952d Aircraft Generation Squadron (952 AGS), under the 552d Operations Group, in December 1995. The unofficial feeling in the wing throughout the two-year test was that the test was just a formality; approval by ACC headquarters to continue after the two years were up was guaranteed. The aircraft generation squadron concept received permanent approval from ACC headquarters in September 1997, the squadron was renamed the 552 AGS, and it was transferred to the 552d Logistics Group. The analysis completed by the 552 ACW senior leadership was limited to anecdotal reactions, with only a topical look at all the maintenance and operations indicators. An in-depth, thorough analysis on the maintenance side was never conducted.

Problem Statement

Has the reorganization resulted in a more effective and more efficient flight line maintenance structure, given the increased operations tempo?

Research Questions

1) Has the Mission Capable rate increased since the reorganization?
2) Has the Not Mission Capable for Supply rate increased since the reorganization?
3) Has the operations tempo increased since the reorganization?
4) Has the AGS structure been more efficient than the FSMU structure?
5) Has the AGS structure been more effective than the FSMU structure?
6) Which maintenance indicators contributed the most to the efficiency of the 552 AGS?
7) Which maintenance indicators contributed the least to the efficiency of the 552 AGS?

Research Hypotheses

1) The Mission Capable rate has shown no increase since the reorganization.
2) The Not Mission Capable for Supply rate has not increased since the reorganization.
3) The operations tempo has not increased since the reorganization.
4) The AGS structure has not been more efficient than the FSMU structure.
5) The AGS structure has not been more effective than the FSMU structure.

Scope and Limitations

The research conducted here focuses solely on E-3 monthly maintenance indicators, from the period of December 1993 to December 1997. This will allow for two years of pre-reorganization analysis, along with two years of post-reorganization analysis.

The data used is from home station operations only (including short deployments within the continental United States). Data from overseas deployments were not included because a different maintenance structure was employed on those deployments. This strictly quantitative study focuses on the analysis of 19 different maintenance indicators. This research also attempts to address some constructs related to changes in organizational effectiveness and efficiency: turnover, manning levels, leadership changes, and seasonal weather patterns

During the first year following reorganization, a high level of turnover (retirements, permanent change of stations, etc) took place in the Senior NCO corps within the 952 AGS for several reasons. The foremost reason was the high degree of turmoil and confusion present during reorganizations. Turnovers were higher in the year following the reorganization than in the year preceding the reorganization. In the second year following the reorganization, Senior NCO turnover returned to the pre-reorganzation level. The Airmen and NCO ranks also featured a fairly high level of separations, relative to the pre-reorganization period, but Airman and NCO retention problems had been increasing in all of ACC throughout the four year period. It is suspected that the reorganization increased the number of separations to some degree, and this will be addressed in the research. The 952 AGS maintained the same commander throughout the test, and his philosophy changed very little. The officers under his command also remained relatively constant.

The 552d Operations Group and 552d Logistics Group commanders both changed once during the test—approximately one year after the reorganization took place. All four commanders would alternate between placing a high priority on getting sorties flown

(at the expense of the health of the aircraft) to getting the aircraft healthy (at the expense of achieving sortie goals). This cyclical nature can be viewed by comparing accomplishment of monthly sortie goals with overall mission capable rates.

Due to the unique characteristics of the E-3 aircraft and the operating environment at its home station, this study may not be applicable to other E-3 aircraft at other locations, or other aircraft in general. The world of aircraft maintenance necessarily works closely with other elements of the aircraft world. Dynamic and changing, it responds to numerous inputs and control factors. What is standard procedure at a base now may not be so in several years. Therefore, the results of this research may have only limited application to future operations at the 552 ACW. Its value lies in showing us what to be aware of—what to look out for.

Another limitation is the accuracy of the maintenance data used. Most of the data was provided to the researcher by the 552 Maintenance Analysis Office, which collected the data off of the Core Automated Maintenance System (CAMS). Some of the data was provided by the headquarters ACC Analysis Office, which collected the data off of the Reliability and Maintainability Information System (REMIS). REMIS derives all of its data directly from CAMS. CAMS is a computer based maintenance management system that tracks all maintenance actions in a wing. CAMS data is accurate only as long as the technicians entering the data enter it correctly and honestly. A few studies have been done on the accuracy of the CAMS data, and this will be addressed in the next chapter.

II. Literature Review

Introduction

Before discussion can begin on the issue of improvements in productivity in an organization, the reasons for consolidation of an organization must be discussed. This chapter focuses on why consolidations occur and what benefits can be derived from them. Next, it addresses the issue of productivity and how productivity has grown in importance over the 1980s and 1990s. After that, it looks at Air Force research on productivity measurement in aircraft maintenance organizations, including seven different master's theses completed at the Air Force Institute of Technology. Finally, this chapter addresses some key constructs that impact any research undertaken on measuring productivity within an aircraft maintenance organization.

Consolidation

The decade of the 1990s has seen a wave of mergers and consolidations in numerous industries (especially defense contracting) in the civilian sector. These mergers and consolidations have occurred for numerous reasons, including increased competition for markets that get increasingly tighter. Companies have tried to increase productivity and reduce costs by consolidating operations. The railroads and the airlines have seen numerous efforts at consolidation.

A 1994 article in the *Economist* entitled, "Casey Jones Had Better Watch His Speed," reported that the railroad industry in the United States has seen some impressive increases in productivity over the last twenty years. In addition to reducing track

networks, the railroads have reduced personnel from 460,000 in 1980 to 193,000 as of 1993. This resulted in a productivity increase of seven percent annually from 1987 to 1992. The CSX railroad implemented an advanced management information system that enabled CSX to consolidate all regional dispatching operations to one location in Jacksonville, Florida. John Andrews, CSX's Director of Information Systems, said that the consolidation was necessary to "reduce manpower, streamline operations, and improve our on-time performance so that we could compete more effectively" (Ruber, 1995: 69).

The airline industry is no stranger to consolidation efforts either. The government's deregulation of the airline industry in the late 1970's led to the demise of some airlines, and to the merger of others. Since the early 1990's, the airlines have focused efforts on consolidation and outsourcing of their maintenance to control costs. An article in *Aviation Week & Space Technology* pointed out:

> Great change is expected over the next 12 to 24 months as airlines accelerate the shift of maintenance work to outside sources. This shift, combined with the steady expansion of the world fleet, will expand maintenance business, not only for competent manufacturers and third-party contractors, but also for airlines who retain the specialty. But until stability returns over the next two years, consolidation and intense price competition will take their toll. (Ott, 1993:40)

The article went on to say that even though aircraft maintenance was considered a cost center in years past, and high costs were tolerated, the "razor sharp competition from low-cost operators has abolished that concept" (Ott, 1993:40). In 1992, roughly eleven percent of the airlines' operating expenses (about $9 billion) was spent on maintaining their fleets (McKenna, 1993:88).

United Airlines has benefited from maintenance consolidations. United performs the bulk of its heavy maintenance at two locations: San Francisco and Oakland, California. In 1993, United implemented their System Aircraft Maintenance Control (SMAC) center in San Francisco. The SMAC monitors all of United's 550 aircraft on a 24 hour, world-wide basis. Its purpose is to serve as a single point agency for helping air crews and maintenance personnel in diagnosing and solving maintenance problems. By identifying and correcting maintenance problems early and quickly, United is able to reduce flight delays and/or cancellations. The personnel operating the center can access individual maintenance records for each aircraft, as well as the necessary technical manuals required for repair (Proctor, 1993:52-53). Through the use of the SMAC, United "expects efficiency gains to trim the costly maintenance process to better compete with low-cost competitors" (Ott, 1993:40). A 1993 article in *Aviation Week & Space Technology* entitled, "United Overhauls Maintenance Operations," explained how United also reorganized its heavy maintenance bases around product lines (such as the 747 or the DC-10), instead of functions (such as avionics repair). Rono J. Dutta, senior vice president of maintenance operations at United, said, "This will better relate reliability and cost of one aircraft [type] to the airline."

Airline consolidation is not limited to the United States, either. In 1993, the Air France group announced the establishment of Air France Industries, an integrated airline maintenance and overhaul division. According to Michel Taret, its executive vice president, the division is "the western world's largest airframe, engine and components maintenance and overhaul organization" (Sparaco, 1993:48). The aim of Air France

Industries is consolidate maintenance facilities, lower overhaul costs, and dominate the European market.

In all of these examples, the primary aim of consolidation was reducing costs by increasing efficiency and productivity—a better use of limited resources. Productivity and efficiency are slippery concepts that need to be addressed further.

Productivity

The concept of productivity measurement is not difficult. "Productivity measures the efficiency with which a production activity converts input into outputs" (Bitran, 1984:30). Stated another way, it is how much output can be obtained with a given amount of input. This is true whether the units of input are dollars, horsepower, or watts of electricity. The basic equation for this is also simple, and is shown in Figure 1:

$$productivity = \frac{Units \cdot of \cdot Output}{Units \cdot of \cdot Input}$$

Figure 1. Basic Productivity Equation (Chew, 1988:111)

The concept of productivity and productivity measurement is not new. In 1676, Sir William Petty, in the book, *Political Arithmetick*, argued for the necessity of quantitative, as opposed to qualitative, measures of observable phenomena, instead of the more commonplace subjective opinion (Kopelman, 1990:127). In the late 1800s, Lord Kelvin wrote, "When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind" (Kopelman, 1990:127). In the United

States, productivity was addressed by the government as early as 1932, when the U.S. Congress appropriated money to the Bureau of Labor Statistics (BLS) to begin tracking and recording labor hours and wages. Shortly after that, the BLS began issuing reports on our nation's productivity levels (Cosgrove, 1986:64). Since that time, numerous other researchers and professionals have published works on the importance of productivity and how to measure it. Professor H. S. Davis, a pioneer in the concept of total factor productivity, published a how-to manual on productivity accounting in 1955, through the University of Pennsylvania's Wharton School of Business (Cosgrove, 1986:64).

Despite the emphasis placed on measuring productivity, U. S. businesses have been slow to adopt and implement systems for measuring overall productivity. As late as 1985, a survey done by Arthur Anderson & Company showed that less than three percent of businesses had implemented any such system (Cosgrove, 1986:64). Several authors (Chew, 1988; Bitran, 1984; Cosgrove, 1986) suggest that the main reason for this is that many managers consider productivity to be an elusive concept, one that they can't quite get their arms around. If the managers can't understand it, they can't very well measure it. In the mid 1980s, the National Aeronautics and Space Administration (NASA) began several initiatives to implement productivity measures in their organization. The NASA leadership subsequently identified two main reasons why NASA was resistant to implementing these measures. The first reason was that the white-collar workers at NASA believed their jobs were too complex for their performance to be measured. The second reason was that those white-collar workers felt the benefits derived from measuring productivity were not worth the added time required to develop and use those

measures (Kinlaw, 1986:32). Those two reasons seem to be applicable to white-collar managers in any organization, not just NASA.

Even though there has been resistance to implementing productivity measures, the research clearly explains why measuring productivity is important. For the U. S. as a whole, decreased productivity can lead to slow (or non-existent) economic growth, higher inflation (and interest rates), and a more unfavorable balance of trade (Bitran, 1984:29). At the firm level, it can result in lower wages, fewer jobs, a lower standard of living, reduced profits due to higher costs, and higher prices in the marketplace (Mammone, 1980:36). Consequently, increased productivity would then result in lower costs, lower prices, higher profits, and a higher standard of living. In the not-for-profit world of the military, this translates into greater output with a reduced cost to the taxpayers.

While some managers may still believe productivity is a subjective concept, the majority opinion in the academic world is that quantitative measures of output and input are needed. One author stated, "While there are some who may define productivity as a state of mind or an attitude, most observers today recognize that the concept demands empirical, standardized metrics" (Kopelman, 1990:127). That same author went on to state, "Focusing on objective measures is not only central to productivity, it is essential to productivity improvements" (Kopelman, 1990:129). In order to measure productivity, numerical measures of output and input must be available. Without that empirical data, it is hard to get any meaningful results.

Another issue that arises in discussions about productivity is the measurement of efficiency versus the measurement of effectiveness. Efficiency is generally thought of as an output to input ratio (as shown in Figure 1), while effectiveness is generally thought of

as "the relationship of outputs to some standard or expectation" (Pritchard, 1987:2). Both measures have been used in the past, but some researchers prefer one over the other. In this research, both measures will be used to assess productivity, and will be discussed further in Chapter 3.

As we have seen, productivity is a concept that wasn't immediately accepted in the business world, but because the concept has merit, it has been gradually adapted and used by corporate managers. The basic concept of productivity is disarmingly simple—output divided by input. Deciding what constitutes output and what constitutes input can get tricky, especially in the military.

Past Air Force Research

Introduction. Since 1980, seven master's theses on aircraft maintenance productivity have been completed at the Air Force Institute of Technology (AFIT) . A search of *Ebsco* and *FirstSearch* revealed that very little scholarly research has been published in academic or professional journals in the last 20 years concerning productivity in Air Force maintenance organizations. These seven theses are interesting not only for what they did find, but also for what methods they used and the limitations inherent in each. Five of the theses, which were published in 1980, 1990, 1991, 1992, and 1993, used linear regression to analyze maintenance indicators (Gray, 1993:17). Managers could perhaps better implement productivity changes if they knew how the independent variables (inputs) affect the dependent variables (output).

Constrained Facet Analysis. The other two theses, which were published in 1984 and 1985, used a technique known as constrained facet analysis (CFA). CFA was

developed by a doctoral student at the University of Texas in the early 1980s as a way to evaluate performance in Air Force units. It is a derivative of data envelopment analysis (DEA), which was developed by Charnes, Cooper, and Rhodes in the late 1970s (Gonnerman, 1984:13). Both CFA and DEA give the relative efficiency of an organization (relative to other similar organizations or to the same organization in a different time frame), utilizing multiple inputs and multiple outputs. Linear regression cannot handle multiple outputs. Unlike regression analysis, CFA does not require the specification of a mathematical production function. CFA, however, does not tell you how the inputs (to what degree) affect the outputs—it just tells you whether that organization is or is not efficient (Bowlin, 1987).

AFIT professor William Bowlin completed a technical report on CFA in 1987. His research suggested that CFA should not be used further until improvements can be made to it. CFA utilizes regression type techniques to perform the analysis, however, CFA utilizes regression incorrectly by considering inputs that fall outside the relevant range of the prediction. This fault in CFA calls into question the reliability of the results. No other research could be located on CFA after 1987, so it will not be used further in this research.

Regression Analysis. The first thesis completed using regression analysis was by Deiner and Hood in 1980. They looked at maintenance quality and sortie generating capabilities in production oriented maintenance organizations. They selected six independent and nine dependent variables for testing, including the fully mission capable rate, manhours per flying hour rate, and the not mission capable for maintenance rate. What was significant about their research is that they found that the maintenance data did

not follow a normal distribution. Therefore, nonparametric statistical analysis was needed to properly derive a model or models (Gray, 1993:17).

The second thesis completed using regression analysis was by Gilliland in 1990. He studied maintenance productivity across the Military Airlift Command (MAC) by analyzing data from six MAC airlift wings. The first phase of his research was to conduct open-ended interviews of senior maintenance managers to determine their definitions of maintenance productivity, and to determine what they felt were the most important maintenance indicators. The second phase of his research was to identify and rank-order the various maintenance indicators in order of significance, classifying each one as an input or as an output. Gilliland used his own 10 years of maintenance experience, plus the results of his phase one interviews, to decide whether a given indicator was an output or an input. Borrowing from DoD definitions of productivity, he stated, "Outputs are defined as the final products produced or services rendered in a measurable functional area. Inputs are defined as the amount of resources utilized to produce an output" (Gilliland, 1990:81). He settled on 13 indicators (see Table 1). In the third phase of his research, he built an *a priori* model to show the relationship of the inputs to the outputs. He then had several other maintenance officers look at the model to assess its validity. Gilliland built a correlation matrix with these variables, and identified those variables that exhibited collinearity. Several variables were removed from the model based on the strength of their correlation. Next, he used step-wise regression to derive six final models for analysis. All variables were regressed to each of the six remaining output variables using backward elimination. One of the six models was found

to contribute most significantly to explaining the productivity output, and was selected as the final model.

Table 1. Gilliland Productivity Measures (Gilliland, 1990:94)

TYPE	VARIABLE NAME	VARIABLE NUMBER
Output	labor hour/flying hour	1
Output	mission capable rate	2
Output	repeat/reoccuring discrepancies	7
Output	maintenance scheduling effectiveness	8
Output	maintenance air aborts	9
Output	homestation reliability	10
Output	enroute reliability	11
Output	training reliability	12
Input	cannibalization	3
Input	awaiting maintenance discrepancies	4
Input	awaiting parts discrepancies	5
Input	average possessed aircraft	6
Input	base self sufficiency	13

The final model was compared with the *a priori* model and the correlation matrix to derive the final logical model (Gilliland, 1990:80-83). The final logical model "supports a multi-level input-output set of relationships between seven of the thirteen productivity measures found through the research process" (Jung, 1991:27-28). Gilliland was interested in the relative strength of correlation between these variables. Those relationships are:

1. Cannibalization rate (CANN/3), awaiting maintenance discrepancies (AWM/4), and average possessed aircraft (POSS/6) correlate negatively, negatively, and positively (respectively) to mission capable rate (MCR/2).

2. Awaiting parts discrepancies (AWP/5) correlates negatively to maintenance scheduling effectiveness (MSE/8).

3. Mission capable rate (MCR/2) and maintenance scheduling effectiveness (MSE/8) correlate negatively and positively (respectively) to labor hour/flying hour (LH/FH). Labor hour/flying hour (1) is the final output to the model. (Gilliland, 1990:106)

Graphically, the final logical model (with correlation matrix values included) is shown in Figure 2. The variables CANN, AWM, and POSS serve as inputs to the output MCR. MCR serves as an input to the final output LH/FH. The variable AWP serves as an input to the output MSE. MSE serves as an input to the final output LH/FH.

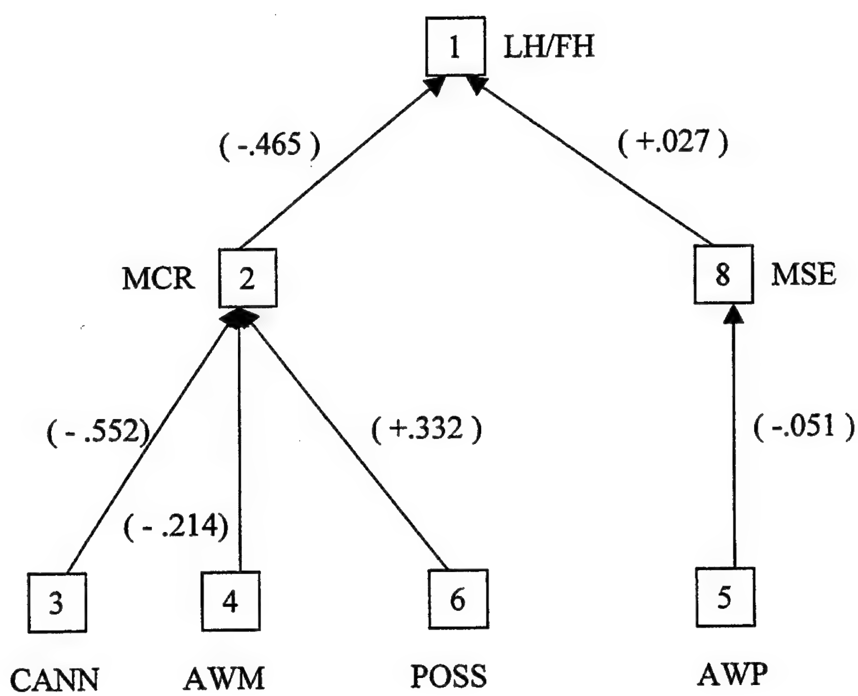


Figure 2. Final Gilliland Model (Gilliland, 1990:106)

Jung (1991) used regression analysis to study maintenance production capability in the Strategic Air Command (SAC). He was able to obtain 21 months worth of data

covering nine different SAC aircraft. He selected 23 independent input variables and three dependent output variables (see Table 2), from which he developed a preliminary model. According to Jung, the output (dependent) variables were selected as such because those were the variables that HQ SAC used to assess maintenance system effectiveness. Those variables that weren't classified as outputs were then classified as inputs. Unlike Gilliland, he didn't specify a relationship between the variables prior to analysis.

Jung used forward stepwise regression to find the best relationship between the inputs and the outputs. He used the first 15 months of data to obtain the preliminary model, then he used the last six months of data to validate his model.

Table 2. Jung Input and Output Variables (Jung, 1991:38-39)

INPUT VARIABLES	
Air Aborts	Not Mission Capable Rate
Air Abort Rate	Not Mission Capable Both Rate
Aircraft Breaks	Not Mission Capable Maintenance Rate
Aircraft Break Rate	Not Mission Capable Supply Rate
Aircraft Fix Rate	Number Aircraft Fixed in 18 Hours
Aircraft Sortie Utilization Rate	Partially Mission Capable Rate
Average Sortie Duration	Partially Mission Capable Both Rate
Cancellations	Partially Mission Capable Maintenance Rate
Cancellation Rate	Partially Mission Capable Supply Rate
Cannibalizations	Possessed Aircraft
Cannibalization Rate	Possessed Hours
Full Mission Capable Rate	Sorties Attempted
Hours Flown	Sorties Flown
Late Take-Offs	Sorties Scheduled
Late Take-Off Rate	**OUTPUT VARIABLES**
Manhours Expended	Mission Capable Rate
Manhours per Sortie	Total Not Mission Capable Maintenance Rate
Manhours per Flying Hour	Total Not Mission Capable Supply Rate

What was significant about Jung's research is that he discovered he had to develop separate models for each type of aircraft. Out of those 23 inputs, he found that only two of them had similar impacts on four of the nine aircraft types evaluated. Jung found that aircraft fix rate appeared prominently for Mission Capable Rate and Total Not Mission Capable Supply Rate on four aircraft types, while the Cancellation Rate appeared prominently for the Total Not Mission Capable Maintenance Rate on four aircraft types (Jung, 1991:110-113). The other 21 inputs had absolutely no commonality. Jung summarized it best by saying, "Maintenance managers that [sic] use performance measures blanketed across all aircraft types and mission environments to judge maintenance performance may find evaluations divergent from reality" (Jung, 1991:115). He recommended that any future research at the aggregate level (such as the major command level) might not be appropriate.

Davis and Walker (1992) applied regression analysis in their research to determine whether the Air Force's reorganization into the objective wing structure resulted in improvement in aircraft maintenance performance factors. They selected the following maintenance indicators as inputs and outputs (see Table 3):

Table 3. Davis and Walker Input and Output Variables (Gray, 1993:71-72)

INPUT VARIABLES
Air Abort Rate
Aircraft Utilization Rate
Maintenance Manhours Per Flying Hour
Not Mission Capable Both Rate
Not Mission Capable Maintenance Rate
Personnel Authorized Per Aircraft
OUTPUT VARIABLES
Mission Capable Rate

Since the Air Force's reorganization was relatively recent at the time of their research, little maintenance data was available for analysis. Davis and Walker compensated for this by attempting to compare Air Force F-15 and F-16 aircraft to the Navy's F-14 and F/A-18 aircraft. They learned (as did Jung) that "the inconsistency of independent variables selected by stepwise regression does not allow direct comparison of different types of aircraft" (Davis, 1992:60)

The last thesis reviewed here to apply regression analysis was Gray and Ranalli's (1993) extension of Davis and Walker's research to see if the objective wing structure did result in improved aircraft maintenance performance. Gray and Ranalli examined the research done by Deiner and Hood, Gilliland, Jung, and Davis and Walker to garner lessons learned and mistakes made. Their study focused on the wing at Fairchild Air Force Base, which included B-52 and KC-135 aircraft. Gray and Ranalli selected the following indicators for analysis (see Table 4):

Table 4. Gray and Ranalli Input and Output Variables (Gray, 1993:25)

INPUT VARIABLES
Abort Rate
Average Possessed Aircraft
Cannibalization Rate
Maintenance Cancel Rate
Delayed Discrepancy Rate
Scheduling Effectiveness
Late Takeoff Rate
Manhours per Flying Hour
Manhours per Sortie
OUTPUT VARIABLES
Mission Capable Rate
Not Mission Capable for Maintenance Rate

Prior to building their model, Gray and Ranalli tested the raw data for normalcy and for autocorrelation. They found that data from only four of the eleven variables were not normally distributed, and that autocorrelation was present in the dependent variable, not mission capable for maintenance rate, for the B-52 aircraft. Autocorrelation (also known as serial correlation) often exists when the data set has a cyclical pattern. This can be observed occasionally in some maintenance indicators, such as the mission capable rate, especially when the changing seasons have a strong impact on the flying. If autocorrelation does exist, then one of the basic assumptions of regression is violated—that the data points be independent of each other. Gray and Ranalli corrected for the autocorrelation by using an autoregressive model. In the results of their study, Gray and Ranalli found that the B-52 and the KC-135 aircraft had different variables in their models. This supports Jung's and Davis and Walker's conclusions that "there is no one universal aircraft maintenance performance model" (Gray, 1993:64). Gray and Ranalli did conclude that the regression models were useful for predicting aircraft maintenance performance, and that the objective wing structure did result in improved aircraft maintenance performance (Gray, 1993:66-67).

Summary of Research. Research into aircraft maintenance productivity is limited, with the focus on analyzing maintenance indicators by categorizing them into two groups: inputs and outputs. Gilliland chose to select an *a priori* model before using regression on the data, while Jung chose to use step-wise regression to build the model, rather than construct it *a priori*. Both approaches produced results that were similar in design—models were constructed that related the significant inputs to the output(s) in some manner. What is clear from this research though, is that one model may not be

appropriate for all types of aircraft designs—it may only be appropriate for the aircraft design it was based on. Mathematically, it can be shown that if the relationship between the inputs and the outputs changes, then the model itself changes. Given that, the same model may not be appropriate year after year on the same aircraft design, if the relationship between the inputs and the outputs changes. What is unclear is how much of a change in that relationship would be needed before the maintenance manager needs to go back and develop a new, better fitting, model.

Key Constructs

Introduction. The data used to perform these past analyses were culled from systems that recorded maintenance and operational data. The analyses were performed using only that data. However, there can be numerous externalities that can affect the outputs also, and must be addressed before continuing any research. These externalities can be (but are not limited to) seasonal weather patterns, turnover in the ranks (at all levels), changes in the leadership, unexpected deployments or exercises that reduce manning at home station, and the accuracy of the data systems used. All of these constructs could have a measured effect on the research results, and must be addressed individually to determine what effect (if any) that they might have on the outputs of the model. These constructs will be addressed in this section.

Seasonal Weather Patterns. When cold weather strikes in the fall and winter, metal rapidly contracts and aircraft sealants (such as on fuel tanks or O rings on hydraulic lines) become less pliable. This results in an increase in unscheduled maintenance, due primarily (but not entirely) to fluid leaks on the aircraft. Cold weather can also cause

hung starts on aircraft engines, and can cause fuel lines to freeze (Department of the Navy, 1988; Ouellette, 1990). Bad winter weather wreaks havoc on the flying schedule, causing more schedule deviations and lost sorties. On the other hand, when spring and summer arrive, the weather improves, sortie rates increase, and the cold weather maintenance problems go away. These seasonal weather patterns are generally reliable and generally easy to forecast. Since they occur at roughly the same time each year, a decrease in productivity during those time periods would not be unexpected. Consequently, statistical analyses can account for some of the changes in productivity due to seasonal weather patterns.

Turnover. In a healthy military organization, there will always be a certain level of turnover due to retirements, separations, and permanent changes of station (PCS). When turnover levels increase dramatically and/or unexpectedly, the impact on productivity needs to be assessed. Research conducted by Sheehan found that turnover can affect job satisfaction and productivity negatively, if the reasons for the turnover are due to a negative attitude about the organization (Sheehan, 1993:5-6). This supports earlier research done by Staw in 1980, which showed that turnover may result in a decrease in productivity, and by Blau in 1973, which showed that high turnover rates may lead to decreased organizational effectiveness (Sheehan, 1993:1). Turnover can also become a vicious cycle, where the rate of turnover keeps increasing (Sheehan, 1993:1). Research was also completed on the effects of turnover on productivity in Army units (squads and platoons). Thirty-one platoons were observed and studied at the Army's National Training Center to see how they performed under combat conditions. The study found that units with less turnover performed better (higher productivity). It also found

that having stability in the leadership positions greatly enhanced productivity (O'Mara, 1989:35-36).

In the context of this research, we must find out if consolidation in an organization leads to increased turnover. James Price, in his 1977 book, *The Study of Turnover*, found that increased centralization in an organization causes an increase in turnover due to decreased individual satisfaction (Price, 1977:76-77). An AFIT thesis on Air Force enlisted aircraft maintenance personnel turnover came to the same conclusion: when an organization consolidates, turnover levels do rise, primarily because individual satisfaction levels decrease (Putt, 1979). Why this happens is made clear by research done by Porter and Steers. When an organization consolidates, it leads to decreased autonomy and decreased responsibility for most of its employees. This decrease in autonomy and responsibility greatly increases turnover (Porter, 1973:164). Another AFIT thesis completed in 1984 supports this finding. Those researchers studied Air Force turnover and found that lower job satisfaction significantly increases turnover (Dunn, 1983:14).

What this implies is that consolidation leads to decreased job satisfaction, which leads to increased turnover. Decreased job satisfaction and increased turnover leads to decreased productivity. For the purpose of this research, a decrease in productivity can be expected within the months following the consolidation (reorganization) move. What is unknown is how much of any decrease in that time frame is a direct result of increased turnover and decreased job satisfaction.

Leadership Changes. Changes in leadership at the flight, squadron, group, and wing levels can have an effect on productivity. Research was done at the Army War

College on the effect of leadership changes on a unit's performance (LaPorte, 1989). This research acknowledged that changes in the leadership do impact unit performance. In fact, excessive change within a unit can lead to chaos (LaPorte, 1989:4). LaPorte went on to conclude, however, that the impact of leadership changes decreases significantly as it occurs higher up the chain of command because higher ranking officers tend to be more homogenous and bureaucratic than lower ranking officers, and because all military personnel are conditioned to accept organizational authority, regardless of who is holding the leadership position (LaPorte, 1989:7-8). Research was also conducted at the Air Force's Air Command and Staff College on the relationship between aircraft mishaps and new commanders (both wing and squadron levels) (McGraw, 1987). This research analyzed Tactical Air Command mishap data and change of command histories from January 1980 to July 1986. McGraw found that at the wing level, a significant portion of the mishaps occurred within the first six months following a wing change of command. At the squadron level, however, McGraw found that more of the mishaps occurred at the 15 to 19 month point (McGraw, 1987:15-17). McGraw surmised that the reason for the increase at the 15 to 19 month point is that the squadron commander was nearing the end of his 2 year tour, and started to let his guard down/started getting lax in enforcing flying rules.

These two studies indicate that changes in leadership can affect an organization's effectiveness (hence, its productivity). LaPorte concluded that the effect decreases as the rank of the leader increases, while McGraw concluded that changes in wing leadership can impact the performance of individuals within a unit. For the purpose of this research, the changes in wing, group, and squadron leadership will be noted. The extent of the

effect of leadership changes, however, will not be easy to determine and will have to be subjectively assessed.

Unexpected Manning Level Changes. Changes in manning levels without a corresponding change in work loads can have an effect on productivity. When an exercise kicks off, or an emergency deployment occurs, the maintenance operations at home station are affected. One often overlooked area is the number of maintenance personnel left behind to continue maintaining the aircraft at home station. A full analysis of this effect would require tracking the numbers of every Air Force Specialty Code (AFSC) at every skill level at the base (or bases) being analyzed. That would add greatly to the complexity of the analysis. Tracking manning levels at the aggregate (wing) level would only be applicable if it could be assumed that all AFSCs were reduced at equal levels. This is an absurd assumption to make, given that some AFSCs are more tightly manned than others. For a major deployment, the data from that time frame could simply be discarded. For smaller, more frequent deployments that affect manning levels, a subjective assessment of the impact of those manning level changes could be made. If deployments occur frequently and in moderate to large numbers (with little variation from month to month), the manning levels due to deployments can be treated as a constant.

CAMS Accuracy. All of the data for this research came from the CAMS database. The accuracy of the CAMS data must be determined before it can be analyzed. In 1991, an AFIT thesis entitled, *Inaccurate Data Entry into the Air Force Maintenance Data Collection System*, researched that question. The author conducted a survey, using a randomly selected sample of all maintenance personnel (of the ranks Airman Basic

through Colonel) from the population of all Tactical Air Command and Strategic Air Command personnel (Determan, 1991:30). The survey was designed to assess the individual's perception of data inaccuracy in CAMS. The results showed that individuals surveyed felt CAMS data was inaccurate 27 percent of the time (mean response). The modal response, however, was that the data was inaccurate 10 percent of the time. The survey also asked the individuals why they thought these inaccuracies existed. The mean response was that 25 percent of the errors were intentional (falsifying work done), with the modal response being only 10 percent (Determan, 1991:61-62).

The Air Force Deputy Chief of Staff for Logistics commissioned a study on the Air Force's maintenance data collection system (including CAMS and REMIS). The report, researched and prepared by a branch of the Department of Transportation, was submitted in 1995. The report, which drew on Determan's research (among others) called into question the accuracy of CAMS data. It found that there was a general belief among maintenance personnel that the data input into CAMS was of little value because no one ever really used it for analysis (Depart of Trans, 1995:24). The report also noted that maintenance personnel received little training on how to use CAMS, and the CAMS system itself was complicated to use (Depart of Trans, 1995:36). All of these problems, of course, could be fixed with the proper levels of training. The report did not cite any new findings on what percentage of CAMS was inaccurate—it just reported (as Determan) user perceptions of the accuracy of CAMS.

A final study was conducted by the Institute for Defense Analyses (IDA) in 1993. First, interviews with senior managers, middle managers, and system users at various logistics, acquisition, operational, and industrial organizations were conducted to

determine what level of data accuracy was really needed. The IDA found that for Reliability and Maintainability analysis, the accuracy requirement was 70 to 90 percent (Devers, 1993:III-5 – III-7). Second, the IDA actually examined REMIS data to determine its accuracy. After analyzing the REMIS data, the IDA found that the accuracy ranged from 68 to 76 percent—in other words, 24 to 32 percent of the CAMS data was inaccurate. This is close to what Determan found in his survey. However, this accuracy (for the most part) fell within the required range (Devers, 1993:V-62).

A response to this report was submitted by Litton Computer Services, contradicting the accuracy of the data. In the response, Litton replied that the Air Force/Litton CAMS/REMIS team had conducted a study in January 1993 on over 1.1 million CAMS transactions, and found an error rate of only 5.38 percent. Litton suggested the IDA study showed a higher error rate because the IDA study analyzed data from REMIS only (which draws its data from CAMS). Litton surmised that REMIS doesn't always transcribe the data accurately from CAMS, and Litton went on to give an example of a transcription error (Devers—Comments on, 1993:IV-43 – IV-44).

In conclusion, there are mixed opinions on the accuracy of CAMS data. The users tend to believe that 10 to 30 percent of the data is inaccurate. One empirical study of the actual data by the IDA showed an error rate of 24 to 32 percent. However, this was contradicted by a similar study that showed an error rate of 5 percent. For the purpose of this research, it will be assumed that the CAMS data is sufficiently accurate. However, minor differences in the results may be due to CAMS data inaccuracy.

Summary

This chapter has shown how consolidation has occurred in civilian companies, for the purpose of improving productivity. The concept of measuring productivity has been around a long time, but it's only gained momentum in the last 15 years. Productivity measurement in Air Force maintenance organizations is an important issue, yet the research on it is limited. Seven theses were completed on it, addressing the relationship of maintenance inputs to outputs. While analyzing maintenance indicators in the manner of those theses is good, researchers must make adjustment for any number of numerous constructs that affect a maintenance organization. The next chapter will address the methodology of this research.

III. Methodology, Findings, and Analysis

Introduction

This chapter addresses the data and data analysis techniques, plus the results of the data analysis, that were used to answer the research questions put forth in the first chapter. In answering those research questions, it may be possible to find an answer to the research problem: has the AGS structure been more efficient and effective than the FSMU structure? Before the research questions could be answered, the maintenance indicators used in the analysis had to be selected and listed, assigned variable names, and categorized as either a measure of efficiency or effectiveness. Second, the sources of the data for the analysis had to be addressed, and the data had to be checked to ensure it meet the requirements of the statistical tests that were used. Finally, the analysis techniques used in this research had to be addressed, including means comparison, step-wise regression, and multiple linear regression, along with the results from those analyses.

Introduction of Maintenance Indicators

The first chapter stated that 19 different maintenance indicators would be used in this analysis. Those indicators were chosen because they represent the most common maintenance indicators in use at the 552 ACW, and because many of those same indicators were used in the prior research discussed in Chapter Two. The 19 indicators are shown in Table 5.

Explanation of the Maintenance Indicators. The abbreviations for the maintenance indicators listed in Table 5 were chosen to simplify the data analysis

Table 5. List of Maintenance Indicators and Abbreviations Used in Data Set

MAINTENANCE INDICATOR	ABBREVIATION
Average Possessed Aircraft	POSS
Mission Capable Rates	MC
Total Not Mission Capable for Maintenance Rates	NMCM
Total Not Mission Capable for Supply Rates	NMCS
Adjusted Aircraft Scheduling Effectiveness Rates	ASE
Controllable Late Take-offs	CLT
Ground Abort Rates	GA
Air Abort Rates	AA
Maintenance Cancellation Rates	MCX
Cannibalization Rates	CANN
Break Rates	BRK
Fix Rates	FIX
Repeat Rates	REP
Recur Rates	REC
Delayed Discrepancy Rates	DD
Planned Utilization Rates:	
Hourly Rates	PHUT
Sortie Rates	PSUT
Actual Utilization Rates:	
Hourly Rates	AHUT
Sortie Rates	ASUT
Maintenance Planning Effectiveness Rates	MEFF
Man-hours per Flying Hour	MFH

process. Some of the abbreviations are identical to the abbreviations used in the field, others are not. The following is an explanation of each maintenance indicator listed above (552 ACW, Oct 97: iii):

Average Possessed Aircraft: Average number of aircraft owned by the wing in a given month. Found by dividing the aggregate number of aircraft possessed hours in a month by the number of hours in that month.

Mission Capable Rate: Percentage of aircraft in a given month that are capable of carrying out at least one of the assigned missions. Found by dividing the aggregate number of Mission Capable aircraft hours in a month by the number of aircraft possessed hours in a month.

Total Not Mission Capable For Maintenance Rate: Percentage of aircraft in a given month that are not capable of carrying out any of the assigned missions due primarily to maintenance reasons. Found by dividing the sum of the aggregate number of Not Mission Capable for Maintenance hours, and the aggregate number of Not Mission Capable for Both Supply and Maintenance hours, by the number of aircraft possessed hours in a month.

Total Not Mission Capable For Supply Rate: Percentage of aircraft in a given month that are not capable of carrying out any of the assigned missions due primarily to supply reasons. Found by dividing the sum of the aggregate number of Not Mission Capable for Supply hours, and the aggregate number of Not Mission Capable for Both Supply and Maintenance hours, by the number of aircraft possessed hours in a month.

Adjusted Aircraft Scheduling Effectiveness Rate: Percentage of aircraft sorties in a given month that take-off and fly as scheduled. Found by dividing the total number of sorties flown (less any deviations) by the number of sorties scheduled (less any non-chargeable deviations).

Controllable Late Take-Off Rate: Percentage of aircraft sorties that take off late due to controllable causes, such as maintenance or supply late deliveries. Found by

dividing the number of controllable late take-offs by the number of sorties scheduled in that month.

Ground Abort Rate: Percentage of aircraft sorties that are canceled due primarily to aircraft maintenance problems that arise after the pilot arrives at the aircraft. Found by dividing the total number of ground aborts by the sum of the total number of ground aborts and the total number of sorties flown in a month.

Air Abort Rate: Percentage of aircraft sorties that are canceled due to mechanical or other problems that arise while in flight. Found by dividing the total number of air aborts by the total number of sorties flown in a month.

Maintenance Cancellation Rate: Percentage of aircraft sorties that are cancelled, before the pilot arrives at the aircraft, due to maintenance problems. Found by dividing the total number of maintenance cancellations by the total number of sorties scheduled in a month.

Cannibalization Rate: Expressed as a percentage, it shows the number of parts (on average) that need to be cannibalized from another aircraft to make one aircraft mission ready. Found by dividing the total number of cannibalized parts by the total number of sorties flown.

Break Rate: Percentage of aircraft that land Code 3 (Not Mission Capable and needing to be fixed before it can fly again) in a given month. Found by dividing the total number of aircraft landing Code 3 by the total number of sorties flown in a given month.

Fix Rate: Percentage of aircraft that landed Code 3 that are fixed within a given time period (12 hours in the 552 ACW). Found by dividing the total number of Code 3s fixed within 12 hours, by the total number of aircraft that landed Code 3.

Repeat Rate: Percentage of maintenance problems fixed that pop up again when the aircraft system is used the very next time. Found by dividing the total number of repeat discrepancies by the total number of pilot reported discrepancies.

Recur Rate: Percentage of maintenance problems fixed that pop up again when the aircraft system is used for the second or third time following repair. Found by dividing the total number of recur discrepancies by the total number of pilot reported discrepancies.

Delayed Discrepancy Rate: Average number of maintenance discrepancies per aircraft that are delayed awaiting parts or maintenance (non-serious discrepancies only). Found by dividing the aggregate total number of delayed discrepancies by the average possessed aircraft in a given month.

Planned Hourly Utilization Rate: Planned number of flying hours (on average) per aircraft per month. Found by dividing the scheduled number of flying hours for that month by the average possessed aircraft for that month.

Planned Sortie Utilization Rate: Planned number of sorties (on average) per aircraft per month. Found by dividing the schedule number of sorties for that month by the average possessed aircraft for that month.

Actual Hourly Utilization Rate: Actual number of flying hours (on average) per aircraft for that month. Found by dividing the total number of hours flown by the average possessed aircraft.

Actual Sortie Utilization Rate: Actual number of sorties flown (on average) per aircraft per month. Found by dividing the total number of sorties flown by the average possessed aircraft.

Maintenance Planning Effectiveness Rate: Percentage of maintenance actions carried out on time, as scheduled. Found by using a formula sheet to assign weighted values to different maintenance actions, then summing up all of those weighted values to determine a total score. This total score is then divided by the maximum score possible to determine the effectiveness rate.

Man-Hours Per Flying Hour Rate: Average number of maintenance man-hours expended for every hour flown. Found by dividing the aggregate number of direct, on-aircraft, maintenance man-hours by the total number of hours flown in that month.

Assignment of Efficiency and Effectiveness Measures. Chapter Two discussed how efficiency is generally though of as an output to input ratio, while effectiveness is generally though of as "the relationship of outputs to some standard or expectation" (Pritchard, 1987:2). In order to answer the research questions, some or all of the maintenance indicators must be tied to either efficiency measures, effectiveness measures, or both.

In any flight line maintenance organization, the primary goal is to put aircraft into the air. If that goal is not met, it is irrelevant whether or not the other goals are being met. Since effectiveness is defined as comparing output to some standard, it makes sense to compare the number of hours and sorties actually flown with the number of hours and sorties planned to be flown to determine effectiveness. If the organization consistently meets those hourly and sortie goals (i.e., flies at least the minimum number of planned sorties and hours for that month), it can be said that it is an effective organization. Two other indicators that relate to effectiveness are Controllable Late Take-offs (CLT) and Maintenance Cancellations (MCX). While it may be argued that CLTs and MCXs are not so much effectiveness measures as efficiency measures, there is good reason to consider these indicators as effectiveness measures also, because CLTs and MCXs directly and visibly impact an organization's ability to put aircraft into the air. To be effective then, an organization would minimize CLTs and MCXs. Thus, for this data set, there are two sets of measures for determining effectiveness: hours and sorties flown (planned versus actual), and CLTs and MCXs. All of the other maintenance indicators relate more to efficiency than to effectiveness.

Efficiency is a ratio of output to input. In a flight line maintenance organization, putting aircraft into the air is not the only output of that organization. Another primary output is maintaining those aircraft in a mission ready state. This output is reflected in the Mission Capable Rate (MC). The input of that organization is man-hours, parts, and equipment. Since parts and equipment availability is a function of funds availability, it can be said that there are only two inputs into a maintenance organization: man-hours and funding. Since this research does not address the funding issues involved in running

a military organization, there is only one input left to focus on: man-hours. The measure of man-hours expended in a maintenance organization is known as the Man-Hours per Flying Hour rate (MFH). Thus, for this data set, efficiency is defined as the ratio of MC rate (output) to MFH rate (input).

The determinants of the MC rate and the MFH rate are many. While the direct measurement of these rates is simple, numerous factors go into them. Many of the 19 maintenance indicators in this data set should have an effect (even slight) on either the MC rate or the MFH rate. Thus, the relationship between the MC rate and the other maintenance indicators had to be determined, along with the relationship between the MFH rate and the other maintenance indicators. This will answer research questions six, seven, and eight: which measures have the greatest and least effect on efficiency?

Key Assumption and Limitations

A key assumption for this analysis was that the data used was sufficiently accurate. If, in reality, the data set utilized in this research was extremely inaccurate, then the analyses used may no longer be valid. The models produced are internally valid, due to the statistical tests used, but the reader must be cautioned not to conclude that causation exists amongst the variables based on the inferences produced by these analyses. While one or more variables may be statistically significant in predicting the Mission Capable rate, the reader should not conclude that causation exists between those variables. Another limit on the internal validity is the relationship between the independent variables in the models. With the maintenance indicators used in this research, a change in one independent variable (e.g. BRK) can have an effect on one or

more other independent variables (e.g. NMCM). The models developed in this research should not be considered externally valid. The models were not validated against current maintenance indicators in the 552d Air Control Wing, so the reader should avoid making predictions of current Mission Capable or Man-Hours per Flying Hour rates in the 552d Air Control Wing. These models do not apply to other aircraft—these models can serve as a reference, but individual models would have to be developed for different aircraft.

Data Characteristics

The data set for this research is shown in Appendix B. Time series plots of the data are shown in Appendix C. All of the data was obtained from the Maintenance Analysis Office under the 552d Logistics Group at Tinker AFB Oklahoma, with one notable exception. The Man-Hours per Flying Hour data from December 1993 to November 1995 was obtained from the Maintenance Analysis Office at ACC Headquarters at Langley AFB Virginia. The data provided by Tinker came in the form of a monthly maintenance digest, which reported maintenance statistics and trends. The data for this digest came directly from CAMS. The data provided by ACC came in the form of a query request from REMIS, which derives its data from CAMS.

For the purposes of analysis, the data set is divided into two groups: a pre-reorganization group (from December 1993 to November 1995) reflecting the maintenance indicators prior to the reorganization, and a post-reorganization group (from January 1996 to December 1997) reflecting the maintenance indicators following the reorganization. The 24 months of pre-reorganization data and the 24 months of post-reorganization data were chosen to provide a somewhat accurate picture of the

maintenance taking place. Data from December 1995 was excluded from the data set because that was the month in which the reorganization took place.

Summary Statistics

Before any comparisons of the data could be made, the data was analyzed to see if it met the necessary assumptions for each statistical test. One of the first assumptions is that of normality of the data. For simple means comparison (using the Student's t-Test) and for simple pairwise correlations (using the Pearson Product-Moment Correlation Coefficient), the data must fit a normal distribution (Kachigan, 1986:147 and SAS, 1995:317). To determine if the data for each variable was normally distributed, the Shapiro-Wilk W test was administered using statistical software. The Shapiro-Wilk W test is a common test for normality used by several statistical packages (for sample sizes up to 2000). It gives a W score, ranging from .000001 to .999999, along with an associated probability value p (Sall, 1996:112). Large values of W are associated with normal distributions; smaller values of W lead to a rejection of the null hypothesis that the data is normally distributed. A common rejection level (the alpha level, α) for statistical analysis is $\alpha = .05$. An alpha of .05 corresponds to a confidence level of 95%; in other words, there is a 95% probability that the conclusion that was drawn is correct. In analyzing this data set, any p value for the Shapiro-Wilk W test that fell below .05 led to the rejection of the null hypothesis and the conclusion that the data for that variable was not normally distributed. The results of the normality test for each variable are shown in Appendix D, and summarized for the key variables in Table 6 below. The

following key variables were found to be not normal: Post NMCS, Pre MC/MFH, Pre MCX, and Pre and Post HOUR and SORTIE GOALS.

Table 6. Shapiro-Wilk W Test Results for Key Variables

VARIABLE	W SCORE	P VALUE	NORMAL?
Pre MC	.966302	.5801	Yes
Post MC	.917875	.0525	Yes
Pre NMCS	.937445	.1470	Yes
Post NMCS	.914543	.0441	**No**
Pre AHUT	.956225	.3747	Yes
Post AHUT	.946563	.2344	Yes
Pre ASUT	.948694	.2606	Yes
Post ASUT	.976299	.8123	Yes
Pre MC/MFH	.718755	<.0001	**No**
Post MC/MFH	.955796	.3673	Yes
Pre CLT	.923010	.0689	Yes
Post CLT	.978737	.8629	Yes
Pre MCX	.862855	.0031	**No**
Post MCX	.939894	.1668	Yes
Pre HOUR GOAL	.894695	.0156	**No**
Post HOUR GOAL	.821011	.0004	**No**
Pre SORTIE GOAL	.857690	.0024	**No**
Post SORTIE GOAL	890870	.0128	**No**

The second assumption that had to be tested was the homogeneity of the variances of the data. The Student's T test assumes that the variances are the same within each group. Since there are two groups in the data set (pre-reorganization and post-reorganization), the variances of each matching variable had to be checked. There are several tests for checking the variances; the statistical software used in this research utilized four tests: Levene, Brown-Forsyth, O'Brien, and Bartlett (Sall, 1996:130). Each test gives an F ratio, with an associated p value. High F ratios correspond to low p

values, which lead to a rejection of the null hypothesis that the variances are equal. An alpha of .05 was the rejection level for this research. If, for this data set, if at least three of the four tests produced p values of .05 or less, then the null hypothesis was rejected and the variances were said to be unequal. The results of these tests on the key variables are shown in Appendix E, and summarized for two of the tests in Table 7 below. The following key variables had unequal variances: MC, NMCS, MCX, and SORTIE GOAL.

The third assumption that had to be tested was that of autocorrelation (or serial correlation). Positive autocorrelation occurs often in time series plots, and can complicate efforts to derive an accurate regression model (Sall, 1996:387). First order autocorrelation occurs when the current value of some variable is correlated with the previous value of that variable. There are different ways to check for autocorrelation of the raw data. The method used in this research was the Runs Test, a feature found in some statistical software packages. The Runs Test can perform autocorrelation assessments for lags of up to several months. A lag occurs when the data is compared to itself after being shifted one or more months. In this research, the Runs Test checked for autocorrelation up to and including 16 lags. The Runs Test calculates the median of the data set, and then counts the number of successive data points found on either side of the median (hence the term "runs"). The number of runs is compared to a predicted number (based on the sample size), and a correlation value is determined based on how far the actual number of runs deviates from the predicted number (Gray, 1993:27). If the number of runs is two standard deviations (or more) away from the predicted number, autocorrelation is present at a significant level. The Runs Test computes both full autocorrelation and partial autocorrelation. Partial autocorrelation tests only the lag in

Table 7. Homogeneity of Variances of Key Variables

VARIABLE	TEST	F SCORE	P VALUE	EQUAL?
MC	Levene	5.7253	.0209	**Unequal**
	O'Brien	4.5882	.0375	**Unequal**
NMCS	Levene	6.4869	.0143	**Unequal**
	O'Brien	6.8350	.0120	**Unequal**
AHUT	Levene	1.9425	.1701	Equal
	O'Brien	.9192	.3427	Equal
ASUT	Levene	.0641	.8012	Equal
	O'Brien	.2380	.6280	Equal
MC/MFH	Levene	1.9199	.1725	Equal
	O'Brien	1.4663	.2321	Equal
CLT	Levene	.4188	.5208	Equal
	O'Brien	.3855	.5377	Equal
MCX	Levene	43.7179	<.0001	**Unequal**
	O'Brien	20.2230	<.0001	**Unequal**
HOUR GOAL	Levene	.0240	.8775	Equal
	O'Brien	.0005	.9825	Equal
SORTIE GOAL	Levene	10.2699	.0025	**Unequal**
	O'Brien	4.5522	.0382	**Unequal**

question (1 month, 2 months, etc.); the effect of the other lags does not influence the outcome. Full autocorrelation allows for the fact that (for example) a 2 month lag could be influenced by a 5 month lag. The results of the Runs Test for the two key dependent variables, MC and MFH, are shown in Appendix F, and summarized in Table 8 below. The variable MC shows significant positive autocorrelation present in the first four lags. The variable MFH shows a very slight (yet significant) positive autocorrelation present in the first lag only. Over all 16 lags though, the test returned a p value of .189, indicating that autocorrelation is not present at a significant level. The partial autocorrelation graphs show that positive autocorrelation is present in both variables in the first lag only

(see Appendix F). It was not necessary to check for autocorrelation in the other variables because none of them served as dependent variables in regression modeling.

Table 8. Runs Test Results for MC and MFH Variables

NOMENCLATURE	MC	MFH
Test Value (Median)	83.050	22.700
Cases < Test Value	24	24
Cases ≥ Test Value	24	24
Total Cases	48	48
Number of Runs	14	20
Z Score	-3.064	-1.313
Asymptotic Significance	.002	.189

Data Analysis Methods and Results

Chapter One presented seven different research questions that needed to be answered. This section addresses the methods used to answer those questions, along with the results. The statistical analysis performed in answering those questions was done using JMP® statistical software by the SAS Institute, Inc. JMP® is a Windows® based version of SAS, although JMP® lacks the capability to do extremely large operations or to incorporate programming into its analysis (SAS, 1995:vii).

Research Question One. *Has the Mission Capable (MC) rate increased since the reorganization?*

Method. Question one was answered by doing a simple means comparison on the variable MC. The pre-reorganization and post-reorganization MC groups were normally distributed; however, their variances were unequal. Consequently, the Student's T test was ruled out and the Welch ANOVA F test was used. The Welch

ANOVA F test is "a one-way ANOVA F test in which the observations are weighted by the reciprocals of the estimated variances" (Sall, 1996:167). Welch ANOVA is commonly used when it is believed that the variances between two groups are not equal. Welch ANOVA computes an F ratio, and an associated p value for that F ratio. The null hypothesis stated that the means of the two groups were equal. The alternate hypothesis stated that the means of the two groups were not equal. The level of significance for this test, and all tests in this research, was $\alpha = .05$, which significantly reduced the chance of a Type I error. Type I errors occur when the null hypothesis is rejected even though it is true (McClave, 1998:319). If the p value was below the alpha level, the null hypothesis was rejected and the means were declared to be not equal. If the means were not equal, and the post-reorganization MC group was higher, then it could be said that the Mission Capable rate had increased since the reorganization.

Findings. The time series plots of pre-reorganization MC and post-reorganization MC (Appendix C) show that the pre-reorganization MC values fell generally between 80% and 90%, with little apparent deviation from the mean. The post-reorganization MC values show a much larger degree of variation, with values that fell generally between 65% and 85%, and an overall downward trend. In the comparison of means (Appendix H) the Welch ANOVA F test produced an F ratio of 41.68, for a p value of less than .0001. The graph of the means also shows that the post-reorganization MC group is lower than the pre-reorganization MC group. Therefore, the null hypothesis is rejected and the means are declared to be not equal, with the post-reorganization MC mean lower than the pre-reorganization MC mean.

Analysis. Based on the results of the F test and the graph, it is easy to see that there is a clear difference in the means of the MC rates. Unfortunately, the MC rate became worse after the reorganization took place. The most dramatic changes in the post-reorganization MC rate occurred between August and December 1997, when the MC rate fell sharply from a post-reorganization high of 86.3% to a post reorganization low of 62.4%, before rebounding to 69.5%. There appears to be no clear reason for that large drop, however, both the NMCM and NMCS rates skyrocketed during that same time frame.

Research Question Two. *Has the Not Mission Capable for Supply (NMCS) rate increased since the reorganization?*

Method. Question two was answered by doing a simple means comparison on the variable NMCS. The pre-reorganization and post-reorganization NMCS groups were not normally distributed and the variances were unequal. Since the distributions were not normal, it required the use of nonparametric analysis. The test chosen was the Wilcoxon Rank Sum Test (also known as the Mann-Whitney U test), a commonly used test for nonparametric means comparisons. The Wilcoxon Rank Sum Test ranks the responses and analyzes the ranks instead of the original data (Sall, 1996:146). The Wilcoxon Rank Sum Test gives a one-way Chi Square approximation, along with an associated p value. The null hypothesis stated that the means of the two groups were equal. The alternate hypothesis stated that the means of the two groups were not equal. The level of significance was $\alpha = .05$. If the p value was below the alpha level, the null hypothesis was rejected and the means were declared to be not equal. If the means were not equal,

and the post-reorganization NMCS group was higher, then it could be said that the Not Mission Capable for Supply rate had increased since the reorganization.

Findings. The time series data plots of pre-reorganization NMCS and post-reorganization NMCS (Appendix C) show that the pre-reorganization NMCS values fell generally between 2% and 8%, with little apparent deviation from the mean. The post-reorganization NMCS values fell generally between 4% and 15%, with a much larger degree of variation. In the comparison of means (Appendix H), the graph shows that the post-reorganization NMCS mean is higher than the pre-reorganization NMCS mean. The Wilcoxon Rank Sum test gave a Chi Square approximation of 11.23, and a corresponding p value of .0008. Therefore, the null hypothesis is rejected and the means are declared to be not equal, with the post-reorganization NMCS mean higher than the pre-reorganization NMCS mean.

Analysis. As with the MC rate comparisons, it is easy to see that there is a clear difference in the means of the NMCS rates, with the post-reorganization NMCS rate higher than the pre-reorganization NMCS rate. What is interesting is the comparison of the two NMCS time series plots. The pre-reorganization NMCS plot is fairly uniform and consistent—the NMCS trend seems to follow a cyclical pattern. Two or three months of increases always seems to be followed by one month of a sharp decrease. The post-reorganization NMCS plot, by contrast, appears to be more erratic with much larger changes in values from one month to the next. The main determinant of the NMCS rate is the availability of parts and the funding to buy and repair parts. Therefore, the NMCS rate is generally beyond the control of the maintenance personnel.

Research Question Three. *Has the operations tempo increased since the reorganization?*

Method. Operations tempo is normally defined by the number of sorties flown in a month, not by the hours flown, since more take-offs and landings require more maintenance work, whereas more hours flown does not necessarily require more maintenance work. This question was answered by doing a comparison of means on the variable ASUT. Since both the pre-reorganization and post-reorganization ASUT groups were normally distributed with equal variances, a simple Student's t-Test could be performed. The Student's t-Test is the most common statistical test used in comparing the means of two groups when the sample size is small, and the distributions are known to be normal with equal variances. The Student's t-Test gives a t value, and an associated p value. The null hypothesis stated that the means of the two groups were equal. The alternate hypothesis stated that the means of the two groups were not equal. The level of significance was $\alpha = .05$. If the p value was below the alpha level, the null hypothesis was rejected and the means were declared to be not equal. If the means were not equal, and the post-reorganization ASUT group was higher, then it could be said that the operations tempo had increased since the reorganization.

Findings. The time series plots for pre-reorganization ASUT and post-reorganization ASUT (Appendix C) show that the pre-reorganization ASUT values fell generally between 6 and 11, with a tendency to have large changes in the ASUT value from one month to the next. The post-reorganization ASUT values fell generally between 8 and 12, with much smaller changes in value from one month to the next. In the comparison of means (Appendix H), the graph shows that the post-reorganization

ASUT mean is slightly higher than the pre-reorganization ASUT mean. The Student's t-Test gave a t score of 1.90, with an associated p value of .0637. Although this p value is close to our alpha of .05, it does not meet the criteria established earlier for rejection of the null hypothesis. Therefore, the null hypothesis cannot be rejected, and the means must be considered to be equal.

Analysis. Because the null hypothesis was not rejected, there is no statistical difference between the pre-reorganization ASUT and post-reorganization ASUT means. Therefore, the operations tempo has not increased since the reorganization. What is interesting in examining the time series plots is that the ASUT rate appears to be increasing in the 24 months prior to the reorganization, but that the general trend following the reorganization (with the exception of the first three months) is downward. In other words, it appears that the operations tempo has been headed downward since the reorganization. No explanation is offered for that trend, but it seems to conflict with the whole idea that the operations tempo was going to increase, thereby requiring a new maintenance structure. It is entirely possible that the ASUT rate was purposely lowered to compensate for the decreased MC rate that the wing was experiencing. No direct evidence was found for this supposition.

Research Question Four. *Has the AGS structure been more efficient than the FSMU structure?*

Method. Earlier in this chapter, efficiency was defined as the ratio of MC to MFH, or simply MC/MFH. This question was answered by calculating the MC/MFH ratio for each of the 24 months in the pre-reorganization and post-reorganization groups, then by doing a means comparison on the two groups. The pre-reorganization group was

found to be not normal, but the variances were equal. This required a Wilcoxon Rank Sum Test on the two groups. The null hypothesis stated that the means of the two groups were equal. The alternate hypothesis stated that the means of the two groups were not equal. The level of significance was $\alpha = .05$. If the p value was below the alpha level, the null hypothesis was rejected and the means were declared to be not equal. If the means were not equal, and the post-reorganization MC/MFH group was higher, then it could be said that the AGS structure had been more efficient than the FSMU structure.

Findings. The time series plots of pre-reorganization MC/MFH and post-reorganization MC/MFH (Appendix C) show that the pre-reorganization MC/MFH values fell generally (with one notable exception) between 2.5 and 4.5. One point on the graph appears to be an outlier, with a value of almost 9. This was due to a drop in the MFH rate from approximately 23 to 10, with a rebound to 22 the following month. While it may appear that this drop was an error, no evidence was found to support that supposition, so the outlier point remained in the analysis. The post-reorganization MC/MFH values fell generally between 2 and 5. There does not appear to be much variation about the means on either time series plot. In the comparison of means (Appendix H), the graph shows that the pre-reorganization MC/MFH mean appears to be slightly higher. The Chi Square approximation gives a score of 1.82, with an associated p value of .1768. This p value is above the alpha level established for rejection of the null hypothesis. Therefore, the null hypothesis cannot be rejected, and the means must be considered to be equal.

Analysis. Because the null hypothesis was not rejected, there is no statistical difference between the pre-reorganization MC/MFH mean and the post-reorganization

MC/MFH mean. Therefore, the AGS structure has not been more efficient than the FSMU structure. What is interesting about the time series plots is that the general trend for the pre-reorganization MC/MFH is upward, while the general trend for the post-reorganization MC/MFH is flat. The time series plots for MC and for MFH were also looked at and compared with the MC/MFH plots to see if either MC or MFH appeared to be more responsible for changes in the MC/MFH rate. A cursory review showed that the MC rate and the MFH rate appeared to influence the MC/MFH rate changes equally.

Research Question Five. *Has the AGS structure been more effective than the FSMU structure?*

Method. Earlier in this chapter, effectiveness was defined as meeting planned sortie and hourly flying goals, while minimizing CLTs and MCXs. This question was answered by calculating an HOUR GOAL and SORTIE GOAL ratio (i.e., AHUT/PHUT and ASUT/PSUT) for each of the 24 months in the pre-reorganization and post-reorganization groups, then by doing a means comparison on HOUR GOAL, SORTIE GOAL, CLT, and MCX. Both the HOUR GOAL groups were found to be not normal, but with equal variances. The SORTIE GOAL groups were found to be not normal and with unequal variances. The pre-reorganization CLT group was found to be not normal and the post-reorganization CLT group was found to be normal, but both groups had equal variances. The pre-reorganization MCX group was found to be not normal and the post-reorganization MCX group was found to be normal, and the variances were unequal. HOUR GOAL, SORTIE GOAL, and MCX required the use of the Wilcoxon Rank Sum test , while CLT used the Student's t-Test. The null hypothesis for each variable stated that the means of the two groups were equal. The alternate hypothesis for each variable

stated that the means of the two groups were not equal. The level of significance was α = .05. If the p value was below the alpha level, the null hypothesis was rejected and the means were declared to be not equal. If the means of SORTIE GOAL and the means of HOUR GOAL were not equal, and the post-reorganization SORTIE GOAL and post-reorganization HOUR GOAL were found to be higher, and if the means of CLT and the means of MCX were not equal and the post-reorganization groups were lower, then it could be said that the AGS structure was more effective than the FSMU structure. However, if the post-reorganization SORTIE GOAL and post-reorganization HOUR GOAL did not both go up, or if the post-reorganization CLT and post-reorganization MCX did not both go down, than it cannot be concluded that the AGS structure was more effective than the FSMU structure.

Findings. In the time series plots (Appendix C), the pre-reorganization HOUR GOAL and the pre-reorganization SORTIE GOAL plots appear to exhibit more variability than the post-reorganization HOUR GOAL and the post-reorganization SORTIE GOAL plots. The pre-reorganization CLT and the post-reorganization CLT plots appear to exhibit equal amounts of variability. The pre-reorganization MCX plot has very little variability, while the post-reorganization MCX plot has a tremendous amount of variability. The comparison of means results (Appendix H) show on the graph that the pre-reorganization HOUR GOAL is slightly higher than the post-reorganization HOUR GOAL. The Chi Square approximation is 5.92, with an associated p value of .0150. Therefore, the null hypothesis is rejected and the HOUR GOAL means are declared to be not equal, with the pre-reorganization HOUR GOAL mean higher than the post-reorganization HOUR GOAL mean. The SORTIE GOAL graph shows that the pre-

reorganization SORTIE GOAL mean is slightly higher than the post-reorganization SORTIE GOAL mean. The Chi Square approximation is 15.89, with an associated p value of less than .0001. Therefore, the null hypothesis is rejected and the SORTIE GOAL means are declared to be not equal, with the pre-reorganization SORTIE GOAL mean higher than the post-reorganization SORTIE GOAL mean. The CLT graph shows that the post-reorganization CLT mean is slightly higher than the pre-reorganization CLT mean. The Student's t-Test gives a t value of 3.7, with an associated p value of .0006. Therefore, the null hypothesis is rejected and the CLT means are declared to be not equal, with the post-reorganization CLT mean higher than the pre-reorganization CLT mean. The MCX graph shows that the post-reorganization MCX mean is higher than the pre-reorganization MCX mean. The Chi Square approximation is 25.67, with an associated p value of less than .0001. Therefore, the null hypothesis is rejected and the MCX means are declared to be not equal, with the post-reorganization MCX mean higher than the pre-reorganization MCX mean.

Analysis. All four of the null hypotheses were rejected. Therefore, the means of each variable group were not equal. For HOUR GOAL and SORTIE GOAL, the post-reorganization means were lower than the pre-reorganization means. Therefore, the AGS structure has been less effective in meeting its hour goals and sortie goals. For CLT and MCX, the post-reorganization means were higher than the pre-reorganization means. Therefore, the AGS structure has been less effective in reducing controllable late take-offs and maintenance cancellations. Since the AGS structure has been less effective in all four measures, the AGS structure has not been more effective than the FSMU structure.

Research Question Six. *Which maintenance indicators contributed the most to the efficiency of the 552 AGS?*

Method. Earlier in this chapter, efficiency was defined as the MC/MFH ratio, and it was stated that numerous maintenance indicators had an effect on both the MC rate and the MFH rate. A pair-wise correlation analysis was performed on all of the maintenance indicators to see which pairs of indicators were highly correlated (either positive or negative). The results of this analysis are shown in Appendix G. Since many of the variables were not normally distributed, a nonparametric correlation analysis had to be performed. There were two measures used in this analysis: Spearman's Rho and Kendall's Tau b. Both of these measures are commonly used in nonparametric correlation analysis. Spearman's Rho is calculated on the ranks of the data, instead of the data itself. Kendall's Tau b is also calculated on the ranks of the data, but bases it on the number of concordant and discordant pairs (SAS, 1995:318). Approximately 95 of the 210 pairs were found to be significantly correlated. Spearman's Rho and Kendall's Tau b differed on only five pairs of variables (see Appendix G) in that list of 95. Table 9 contains the covariate correlation results for MC and MFH versus all the other variables. Using a significance level of $\alpha = .05$, the table shows that ten variables are significantly correlated with MC, and one variable is possibly significantly correlated with MC. The ten significant variables are: NMCM, NMCS, ASE, CLT, GA, MCX, BRK, FIX, DD, and PHUT. The one possibly significant variable is PSUT. All eleven variables have correlation values that are statistically significant at the $\alpha = .05$ level, which means that all eleven variables should be excellent predictors of the MC rate. For the MFH column, there were no significantly correlated variables at the $\alpha = .05$ level. At the $\alpha = .10$ level

however, three variables appeared to be significantly correlated with MFH. Those three variables are: BRK, DD, and AHUT. The correlation values of those three variables were relatively weak, ranging from -.23 to -.26. While the variable MC appears to have several independent variables that could serve as good predictors, the variable MFH does not. To fully understand the effect the independent variables had on MC and MFH, regression analysis was needed. Regression analysis took into effect the apparent relationships between the independent variables—something that correlation analysis could not do.

Table 9. Covariate Correlation Results for MC and MFH

	MC				**MFH**			
Covariate	*Rho*	*p*	*Tau b*	*p*	*Rho*	*p*	*Tau b*	*p*
POSS	-.0999	.4993	-.0378	.7085	-.0676	.6478	-.0360	.7217
MC	---------	-------	---------	-------	.0649	.6611	.0492	.6246
NMCM	**-.9595**	.0001	**-.8437**	.0000	-.1160	.4325	-.0759	.4497
NMCS	**-.8397**	.0001	**-.6625**	.0001	.0602	.6843	.0349	.7286
ASE	**.7681**	.0001	**.5730**	.0001	.0838	.5713	.0766	.4444
CLT	**-.5587**	.0001	**-.3900**	.0001	-.2022	.1681	-.1362	.1762
GA	**-.3946**	.0055	**-.2843**	.0049	.1160	.4323	.0820	.4179
AA	-.2498	.0869	-.1647	.1017	-.1360	.3567	-.0942	.3502
MCX	**-.7654**	.0001	**-.5907**	.0001	-.0061	.9674	-.0082	.9359
CANN	-.1995	.1739	-.1419	.1573	.1228	.4057	.0796	.4285
BRK	**-.7280**	.0001	**-.5477**	.0001	**-.2620**	.0720	**-.1787**	.0752
FIX	**.4614**	.0010	**.3316**	.0009	.0413	.7806	.0268	.7896
REP	-.2794	.0544	-.1883	.0639	-.0599	.6858	-.0453	.6560
REC	-.1833	.2123	-.1098	.2808	-.1501	.3084	-.0909	.3726
DD	**-.6732**	.0001	**-.4864**	.0001	**-.2423**	.0970	**-.1654**	.0998
PHUT	**-.4735**	.0007	**-.3224**	.0013	-.2078	.1565	-.1534	.1261
PSUT	**-.3227**	.0253	-.1974	.0512	-.1253	.3963	-.0930	.3590
AHUT	-.2447	.0937	-.1651	.0999	-.2371	.1047	**-.1672**	.0962
ASUT	.0521	.7249	.0314	.7554	-.1423	.3345	-.0891	.3728
MEFF	.0806	.5858	.0538	.6051	-.1602	.2768	-.1135	.2762
MFH	.0649	.6611	.0492	.6246	---------	-------	---------	--------

Only data from the post-reorganization group was used to develop the regression models used to answer this research question, since the post-reorganization group data resulted from the AGS structure. Models were developed from the pre-reorganization group data however, to allow for pre-reorganization and post-reorganization comparisons. Even though the assumptions of normality and equal variance were not satisfied for all the variables in the data set, regression modeling was still used. The F test used with ANOVA in regression modeling "is but little affected by lack of normality, either in terms of the level of significance or power of the test. Hence, the F test is a robust test against departures from normality" (Neter, 1990:623). As for the problem of unequal variances, the F test is "robust against unequal variances when the sample sizes are approximately equal" (Neter, 1990:624). Since the sample sizes were equal in this research, the unequal variances were not a problem in using regression modeling. Analysis of the residuals was performed to ensure reasonableness of the departures from normality and homoscedasticity.

The four models developed were: the pre-reorganization MC model, the pre-reorganization MFH model, the post-reorganization MC model, and the post-reorganization MFH model. The techniques used to develop the pre-reorganization and post-reorganization models were the same, and will be discussed in terms of the post-reorganization models only for the next several paragraphs. The initial full post-reorganization MC model had post-reorganization MC as the dependent variable, with all the other post-reorganization variables entered in as independent variables. The initial full post-reorganization MFH model had post-reorganization MFH as the dependent variable, with all the other post-reorganization variables (including post-reorganization

MC) as the independent variables. To help correct for the autocorrelation found in both the MC and MFH variables, one month lag variables (Lag1 MC and Lag1 MFH) were created and entered into the full models prior to performing the regression. Stepwise regression analysis was used to find the statistically significant independent variables that influenced the dependent variable and discard the variables that were not significant. For the post-reorganization MC, pre-reorganization MC, and pre-reorganization MFH variables, both the probability to leave and the probability to enter were set at .05, to correspond with the alpha level used earlier in this research. Stepwise regression removed the variables that were not significant at that alpha level. For the post-reorganization MFH variable, both the probability to leave and the probability to enter were set at .10, since stepwise regression removed all but one of the independent variables at the $\alpha = .05$ level.

Once the stepwise regression was completed, the sets of significant independent variables were used to form reduced regression models for post-reorganization MC and post-reorganization MFH using the standard least squares method. The statistical software produced an overall adjusted R Square value for the model, with F ratios and associated p values for each of the independent variables. The adjusted R Square value indicates how much of the variation in the data is explained by the model, and can range from 0 to 1. Therefore, the higher the R Square value, the better the fit of the model. The software also gives a whole model F ratio (and p value) to determine if the intercept term alone is enough to predict the value of the dependent variable. The higher the F ratio, the more likely it is that the intercept term alone cannot predict the value of the dependent variable, so the conclusion is drawn that at least one independent variable must be in the

model. The deciding p value for rejecting the intercept term only model is the alpha level of .05. Any p value below that indicates that the intercept term only model should be rejected. The F ratios also indicate how significant an impact each independent variable has on the dependent variable. The higher the F ratio, the lower the p value. Since $\alpha =$ .05 for this research, any p value below .05 indicated that the independent variable in question belonged in the model, and that the variable in question correlated strongly with the dependent variable. Those variables remaining in the model were the ones that appeared to contribute the most to the efficiency of the 552 AGS.

To check for autocorrelation of the final models, a Durbin-Watson test was performed on each model after the regression. Durbin-Watson is a common test for first-order autocorrelation (1 lag only), and produces a score ranging from 0 to 4. Scores that approach 2 indicate that autocorrelation is not present. Scores that approach 0 indicate that positive autocorrelation is present. Scores that approach 4 indicate that negative autocorrelation is present. As was stated earlier in this chapter, positive autocorrelation is a common feature in time series data; negative autocorrelation is not common at all in time series data (Neter, 1990: 491). The statistical software used in this research gave a Durbin-Watson score, along with an associated p value for positive autocorrelation only. If the final regression models had shown significant positive autocorrelation, it would have been necessary to revise the models.

To further check the final regression models, the residuals were plotted and visually checked to see that they were randomly distributed about the mean with no apparent quadratic or other non-linear influences showing. The residuals were also checked for normality using the Shapiro-Wilk W test (described earlier in this chapter).

Once all the tests had been performed to see that the models provided a good fit and were valid, question six could finally be answered. The variables remaining in the final post-reorganization MC and final post-reorganization MFH regression models were the ones that contributed the most to the efficiency of the 552 AGS.

Findings. All results are shown in Appendix I. Table 10 contains the regression results for the two MC models, while Table 11 contains the regression results for the two MFH models. Stepwise regression of the post-reorganization MC variable left the following variables in the model at the $\alpha = .05$ level of significance: POSS, NMCM, NMCS, ASE, GA, MCX, CANN, FIX, DD, PHUT, AHUT, ASUT, MEFF, and Lag1 MC. The standard least square regression method produced the final model shown in Table 10, with an adjusted R Square value of .9939. The whole model F ratio was 267 with a p value of less than .0001, so the intercept term alone was not sufficient to predict the MC variable. All the remaining independent variables within the model had F ratios and associated p values that fell below the $\alpha = .05$ level of significance, so those variables shown in Table 10 were left in the model. The Durbin-Watson score of the final post-reorganization MC model was 2.963, with an associated p value of .956. This indicates that positive autocorrelation was not present in the final model. The plot of the residuals (also in Appendix I) appeared to be randomly and equally distributed about the mean, with no apparent quadratic influences present. The Shapiro-Wilk W score of the residuals was .947924, with an associated p value of .2509. Therefore, the residuals are normally distributed. The regression assumptions have been reasonably met for the post-reorganization MC model.

For the pre-reorganization MC model, stepwise regression left the following variables in at the $\alpha = .05$ level of significance: NMCM, NMCS, ASE, CLT, CANN, BRK, FIX, ASUT, MEFF, MFH, and Lag1 MC. The adjusted R Square value was .98732, with a whole model F ratio of 156.7 and an associated p value of less than .0001. The Durbin-Watson score was 2.110 with an associated p value of .3893, so positive autocorrelation is not present in the model. The Shapiro-Wilk W score of the residuals was .942153, with an associated p value of .2017, so the residuals are normally distributed. The plot of the residuals appeared to be randomly and equally distributed about the mean, with no apparent quadratic influences present. The regression assumptions have been reasonably met for the pre-reorganization MC model.

Stepwise regression of the post-reorganization MFH variable (Table 11) left the following variables in the model at the $\alpha = .10$ level of significance: POSS, MC, NMCM, NMCS, AA, and BRK. The standard least square regression method produced the final model shown in Table 11, with an adjusted R Square value of .3519. The whole model F ratio was 3.08 with a p value of .0315, so the intercept term alone was not sufficient to predict the MFH variable. All the remaining independent variables within the model had F ratios and associated p values that fell below the $\alpha = .10$ level of significance, so those variables shown in Table 11 were left in the model. Only one variable, NMCM, had a p value that fell between .05 and .10—all other p values were below .05. The Durbin-Watson score of the final post-reorganization MFH model was 2.458, with an associated p value of .789. This Durbin-Watson score indicates that positive autocorrelation is not present in the final model. The plot of the residuals appeared to be randomly and equally distributed about the mean, with no apparent

Table 10. Regression Results for MC Models

Pre-Reorganization MC Model

R Square =	.99366	*Adj R Square =*	.98732
Term	*Estimate*	*F Ratio*	*Prob > F*
Whole Model	-------------	156.7229	<.0001
Intercept	15.790253	1.1236	.3110
NMCM	-.760885	228.8829	<.0001
NMCS	-.768260	280.2243	<.0001
ASE	.265451	12.7656	.0044
CLT	.322276	10.9603	.0069
CANN	.124310	27.0217	.0003
BRK	.113466	6.9243	.0233
FIX	.023299	7.6887	.0181
ASUT	1.123302	28.9885	.0002
MEFF	.303544	21.3928	.0007
MFH	.051629	5.0973	.0453
Lag1 MC	.100157	6.6402	.0257

Post-Reorganization MC Model

R Square =	.997599	*Adj R Square =*	.993863
Term	*Estimate*	*F Ratio*	*Prob > F*
Whole Model	-------------	267.0731	<.0001
Intercept	112.567480	267.6496	<.0001
POSS	-.729614	6.5653	.0306
NMCM	-.510969	39.8298	.0001
NMCS	-1.083916	180.5625	<.0001
ASE	-.107712	11.8342	.0074
GA	-.888746	44.0146	<.0001
MCX	-.154877	8.9311	.0152
CANN	.068173	16.9566	.0026
FIX	.122959	29.9323	.0004
DD	.114714	14.7542	.0040
PHUT	-.091255	20.1068	.0015
AHUT	-.178391	20.3371	.0015
ASUT	1.407574	12.0015	.0071
MEFF	-.127548	10.4044	.0104
Lag1 MC	.111208	10.8595	.0093

quadratic influences present. The Shapiro-Wilk W score of the residuals was .937646, with an associated p value of .1485. Therefore, the residuals are normally distributed. The regression assumptions have been reasonably met for the post-reorganization MFH model.

For the pre-reorganization MFH model, stepwise regression left the following variables in at the $\alpha = .05$ level of significance: MC, NMCM, NMCS, ASE, CLT, CANN, BRK, FIX, ASUT, MEFF, and Lag1 MC. The adjusted R Square value was .642933, with a whole model F ratio of 4.6012 and an associated p value of .0089. The Durbin-Watson score was 2.534 with an associated p value of .8298, so positive autocorrelation was not present in the model. The Shapiro-Wilk W score of the residuals was .980965, with an associated p value of .9101, so the residuals are normally distributed. The plot of the residuals appeared to be randomly and equally distributed about the mean, with no apparent quadratic influences present. The regression assumptions have been reasonably met for the pre-reorganization MFH model.

Analysis. The final post-reorganization MC model (Table 10) contained 14 of the original 21 variables entered into the model prior to stepwise regression. The fact that only seven variables were excluded seems to support the idea that the determinants of the mission capable rate are many—that the determinants can't be isolated down to just three or four variables. In comparing the variables in the final post-reorganization MC model with the results of pairwise correlation (Appendix G), there were five variables in the model that were not significantly correlated with MC in the pairwise correlation table. The variables (and their Spearman Rho scores) are: POSS (-.0999), CANN (-.1995), AHUT (-.2447), ASUT (.0521), and MEFF (.0806). Scores closer to –1 or 1 indicate

Table 11. Regression Results for MFH Models

Pre-Reorganization MFH Model			
R Square =	.821466	*Adj R Square =*	.642933
Term	*Estimate*	*F Ratio*	*Prob > F*
Whole Model	-------------	4.6012	.0089
Intercept	-22.068950	.0225	.8804
MC	6.556485	11.2014	.0065
NMCM	5.213891	11.4320	.0061
NMCS	4.625075	9.8118	.0095
ASE	-2.299444	24.0243	.0005
CLT	-2.911190	21.9373	.0007
CANN	-.9659360	18.5162	.0012
BRK	-.9265050	11.9521	.0054
FIX	-.2418590	12.7009	.0044
ASUT	-8.3863350	23.8411	.0005
MEFF	-2.5746330	12.3202	.0049
Lag1 MFH	.4947202	6.0780	.0314
Post-Reorganization MFH Model			
R Square =	.520953	*Adj R Square =*	.351878
Term	*Estimate*	*F Ratio*	*Prob > F*
Whole Model	-------------	3.0812	.0315
Intercept	227.327080	8.3521	.0102
POSS	4.014337	6.3269	.0222
MC	-2.693023	9.1586	.0076
NMCM	-1.240222	3.6829	.0719
NMCS	-1.615171	5.2726	.0346
AA	-2.393697	7.2299	.0155
BRK	-.061945	8.5834	.0094

high levels of correlation. With an adjusted R Square value of .9939, the fit of the model is extremely good—the model accounts for over 99% of the variation present in the data. In comparing the post-reorganization MC model with the pre-reorganization MC model, a clear difference appeared. The pre-reorganization model only had 11 variables in it,

eight of which were common with the post-reorganization model. The eight common variables were: NMCM, NMCS, ASE, CANN, FIX, ASUT, MEFF, and Lag1 MC. The pre-reorganization MC model contained the variables CLT, BRK, and MFH, which the post-reorganization MC model did not contain. The post-reorganization MC model contained the variables POSS, GA, MCX, DD, PHUT, and AHUT, which the pre-reorganization MC model did not contain. In examining the signs of the beta values of the variables in the post-reorganization MC model, some of them seem to make sense, but others do not. For example, the post-reorganization MC model shows that there is an inverse relationship between the number of Possessed aircraft (POSS) and the Mission Capable (MC) rate, and that there is a direct relationship between the Fix rate (FIX) and the Mission Capable rate. The former is counterintuitive, while the latter makes sense. If POSS increases, then the MC rate should increase too, because there would be larger numbers of healthy aircraft (given that the operations tempo remains constant). To explain this disparity, the model must be examined in the aggregate. The assumption that one variable in the model could change without any of the other variables also changing is false—a change in one variable can affect other variables in the model. Thus, in the example above, if POSS increases, it may change enough other variables to cause the MC rate to rise.

The final post-reorganization MFH model (Table 11) contained six of the original 21 variables entered into the model prior to stepwise regression. In comparing the variables in the final post-reorganization MFH model with the results of pairwise correlation (Appendix G), none of the six variables in the model were significantly

correlated with MFH in the pairwise correlation table. The Spearman Rho scores for the variables were: POSS (-.0676), NMCM (-.1160), NMCS (.0602), BRK (-.2620), AA (-.1360), and MC (.0649). Scores closer to –1 or 1 indicate high levels of correlation. Given that the pairwise correlation scores were low, it's not surprising that the adjusted R Square score for the model was only .3519—not exactly a good fit, but it was the best fit available given the independent variables chosen. It is quite possible that there are one or more other variables out there that have a greater influence on the MFH rate, which could be a topic for further research. In comparing the post-reorganization MFH model with the pre-reorganization MFH model, a clear difference appeared. The pre-reorganization MFH model had 11 variables in it, four of which were common with the post-reorganization MFH model. The four common variables were MC, NMCM, NMCS, and BRK. The pre-reorganization MFH model contained the variables ASE, CLT, CANN, FIX, ASUT, MEFF, and Lag1 MFH, which the post-reorganization MFH model did not contain. The post-reorganization MFH model contained the variables POSS and AA, which the pre-reorganization MFH model did not contain.

This research question asked, "Which maintenance indicators contributed the most to the efficiency of the 552 AGS?" The answer is the variables that were in either the post-reorganization MC model or the post-reorganization MFH model: POSS, NMCM, NMCS, ASE, GA, MCX, CANN, FIX, DD, BRK, AA, MC, PHUT, AHUT, ASUT, and MEFF.

Research Question Seven. *Which maintenance indicators contributed the least to the efficiency of the 552 AGS?*

Method. This question was answered in answering question number six above. The variables that were excluded from the final post-reorganization MC and final post-reorganization MFH regression models contributed the least to the efficiency of the 552 AGS.

Findings. After completing regression analysis, only four variables were left that were not used in either the MC model or the MFH model: CLT, REP, REC, and PSUT.

Analysis. While the four variables listed above were excluded from both models, caution must be used in deciding that they don't play a role in the efficiency of the 552 AGS. Stepwise regression removes variables that exhibit collinearity with other independent variables. In other words, the four variables listed above could very well have correlated strongly with one or more variables that were left in the model. The only reason then that these variables were excluded would be because they didn't fit the model as well as their collinear partners. It would be an incorrect assumption to state that the four variables listed above do not contribute anything to the efficiency of the 552 AGS. Those four variables just do not contribute as much as the variables that were included in the final models.

Summary

This chapter addressed the data and data analysis techniques, plus the results of the data analysis, that were used to answer the research questions put forth in the first chapter. First, the maintenance indicators used in the analysis were selected and listed,

assigned variable names, and categorized as either a measure of efficiency or effectiveness. Second, the sources of the data for the analysis were addressed, as were the methods for checking the data to ensure it met the requirements of the statistical methods used. Finally, the analysis techniques used in this research were addressed, including means comparison, step-wise regression, and multiple linear regression, along with the results from those analyses. In the next chapter, the results will be interpreted and inferences will be drawn.

IV. Conclusions and Recommendations

Introduction

This chapter presents the conclusions of the research effort and recommends areas for further research. Each of the seven research questions identified in Chapter One are presented again with the answers obtained from this research, with their implications. Finally, some recommendations for further research are offered.

Results

Here are the seven research questions and their associated answers, along with a brief discussion of their implications.

Research Question One. *Has the Mission Capable rate increased since the reorganization?*

The Mission Capable (MC) rate did not increase—in fact, it decreased—after the reorganization (see Analysis on page 45). Aircraft maintenance personnel are often judged by what kind of MC rate is maintained in an organization. In fact, the MC rate is often the prime determinant of success or something less than success. Since the MC rate decreased following the reorganization, the temptation would be to say that the reorganization was a failure. There are other determinants, however, that need to be considered, such as the Not Mission Capable for Supply Rate.

Research Question Two. *Has the Not Mission Capable for Supply rate increased since the reorganization?*

The Not Mission Capable for Supply (NMCS) rate did increase after the reorganization (see Analysis on page 46). While the NMCS rate before the reorganization ranged from 2% to 8%, after the reorganization the NMCS rate ranged from 4% to 15%. The NMCS rate and the MC rate are inversely proportional—as the NMCS rate rises, the MC rate will fall by an equal amount. This explains some of the drop in the MC rate following the reorganization, although it cannot be assumed that the NMCS rate increase explains all of the MC rate drop. Since the NMCS rate is a function of parts availability and funding, the NMCS rate is generally beyond the control of maintenance personnel. In answering Research Question One, the reorganization appeared to be a failure. After answering Research Question Two, that conclusion was no longer certain.

Research Question Three. *Has the operations tempo increased since the reorganization?*

In terms of defining the operations tempo as the actual sortie utilization rate (ASUT), the operations tempo has not increased since the reorganization (see Analysis on page 48). No statistical difference was found between the pre-reorganization ASUT mean and the post-reorganization ASUT mean. The trend line prior to the reorganization appeared to be upward. The trend line following the reorganization, however, appeared to be downward. In other words, the conclusion could be made that the operations tempo has been decreasing since the reorganization. It is entirely possible that the ASUT rate was purposely lowered to compensate for the decreased mission capable rate that the wing was experiencing.

Research Question Four. *Has the AGS structure been more efficient than the FSMU structure?*

In terms of defining efficiency as the ratio of the mission capable (MC) rate to the Man-hours per Flying Hour (MFH) rate, MC/MFH, the AGS structure has not been more efficient than the FSMU structure (see Analysis on page 49). No statistical difference was found between the pre-reorganization MC/MFH mean and the post-reorganization MC/MFH mean. In fact, the trend line for the pre-reorganization MC/MFH data appeared to be upward, while the post-reorganization MC/MFH data appeared to be flat.

Research Question Five. *Has the AGS structure been more effective than the FSMU structure?*

This research defined effectiveness as meeting both Hour and Sortie goals while minimizing Controllable Late Take-offs and Maintenance Cancellations. In those terms, the AGS structure has not been more effective than the FSMU structure (see Analysis on page 52). Both Hour and Sortie Goal accomplishment rates fell after the reorganization, while Controllable Late Take-offs and Maintenance Cancellations increased after the reorganization.

Research Question Six. *Which maintenance indicators contributed the most to the efficiency of the 552 AGS?*

The maintenance indicators that contributed the most to the efficiency of the 552 AGS are: Average Possessed Aircraft (POSS), Total Not Mission Capable for Maintenance (NMCM) rate, Total Not Mission Capable for Supply (NMCS) rate, Adjusted Aircraft Scheduling Effectiveness (ASE) rate, Ground Abort (GA) rate, Maintenance Cancellation (MCX) rate, Cannibalization (CANN) rate, Fix (FIX) rate,

Delayed Discrepancy (DD) rate, Break (BRK) rate, Air Abort (AA) rate, Mission Capable (MC) rate, Planned Hourly Utilization (PHUT) rate, Actual Hourly Utilization (AHUT) rate, Actual Sortie Utilization (ASUT) rate, and Maintenance Efficiency (MEFF) rate (see Findings and Analysis on pages 58-64). Each variable in the list above is a contributor in the determination of the MC rate, the MFH rate, or both. Each variable will contribute different amounts to the determination of either the MC rate or the MFH rate, so it is difficult to rank the variables in degree of influence without more extensive statistical analysis, which could be the subject for future research.

Research Question Seven. *Which maintenance indicators contributed the least to the efficiency of the 552 AGS?*

The maintenance indicators that contributed the least to the efficiency of the 552 AGS are: Controllable Late Take-offs (CLT), Repeat (REP) rate, Recur (REC) rate, and Planned Sortie Utilization (PSUT) rate (see Findings and Analysis on page 65). While these four variables contributed to least to efficiency, it cannot be assumed that they had no effect on efficiency—that has not been proven by this research.

Conclusions and Implications

The primary conclusion to be drawn is that the reorganization that took place in December 1995 at the 552d Air Control Wing has not resulted in a more efficient or a more effective flight line maintenance structure. What remains unseen is what would have happened if there had been no reorganization. Would the existing (pre-reorganization) structure have shown decreases in efficiency and effectiveness like the AGS structure did? If so, which structure would have caused the least damage by

keeping efficiency and effectiveness from falling too far? Is there another maintenance structure out there that could have actually increased efficiency and effectiveness during that same time period under those same conditions? If this analysis had been performed promptly at the end of the AGS test period, it would have been prudent to make changes to the structure at that time.

It has been two years since the AGS test period ended, and no analysis similar to this research has been performed to see if efficiency and effectiveness have reversed course and began to improve. It would be very interesting to see an analysis comparing the first two years of the reorganization with years three and four following the reorganization. If the trends were still downward after that, it would seem that changes would need to be made—the sooner the better.

One key limitation of this analysis must be pointed out. The research was performed using means comparison and stepwise regression on maintenance data between December 1993 and December 1997. The results of this research should not be taken and applied to maintenance data either before or after the time frame listed above. To do so could cause serious errors to be introduced into any analyses. The value of this research was in showing how an analysis could be done. It is not necessarily the only way to do an analysis of efficiency and effectiveness—other researchers may have and choose their own methods.

Recommendations for Further Research

This research was not the first on maintenance effectiveness and efficiency, and it is hopefully not the last. During this research several concepts arose that present opportunities for future research.

1. In developing a regression model for Man-hours per Flying Hour (MFH), it appeared that there may be other determinants beyond maintenance indicators that would more fully explain how the MFH rate is determined. Research into such factors as skill levels, manning levels, and funding, should be conducted to see if those factors have a strong influence in determining the MFH rate.

2. There appears to be a real shortage of analysis on the accuracy of CAMS data. While studies have been conducted on users' perceptions of the accuracy of CAMS, little has been done to actually measure the accuracy (or lack thereof). An intensive study over several bases and MAJCOMS might provide a wealth of information to either back up or disprove the users' perceptions of CAMS data accuracy. It would also lend more credibility to any studies being done utilizing CAMS or REMIS as a source for data.

3. In determining what variables contributed the most to efficiency, this research had to stop short of actually ranking them, due to the number and complexity of the variables and how those variables were actually weighted in the regression models. It would be interesting to fully analyze these variables, taking into account their means, variances, and beta values, to come up with a method for determining if the variables can actually be ranked from most significant to least significant.

4. As was addressed earlier in this chapter, it would be interesting to have this same analysis done on the 552 ACW, comparing years one and two (following the

reorganization) with years three and four (following the reorganization). Would there be any big changes? If so, could those changes be attributed to only one or two factors?

5. Professional maintenance officers and logisticians would benefit from a formula for predicting what the mission capable rate would be at the end of any given month. Derive a method (using regression analysis or some other technique) that is robust enough to be used at a given wing to predict the MC rate for the coming month. Past research has shown that prediction models haven't worked across different aircraft, so the prediction method would have to be aircraft (Mission-Design-Series) specific.

6. This research did not focus on such factors as funding levels, skill levels, manning levels, morale levels, and so on. It would be interesting to conduct this same (or similar) type of research while including such factors as listed above. Intuitively, those factors above should have an impact—the degree of which is unknown.

7. Conduct research into the effects of seasonality on aircraft maintenance effectiveness and efficiency. Don't just restrict seasonality to the weather, also include factors such as higher Permanent Change of Station rates in the summer, the effect of the Thanksgiving/Christmas time holidays, and so on.

8. Do a study on the effect of turnover at different levels within a maintenance organization to see what effect it has on efficiency and effectiveness. Examine Airmen, Non-Commissioned Officer, Senior Non-Commissioned Officer, Company Grade Officer, and Field Grade Officer ranks to determine if turnover in some ranks has more effect on efficiency and effectiveness than turnover in other ranks.

Summary

This research has examined the effect an organizational restructuring of a maintenance organization had on that organization's effectiveness and efficiency. The goal was to determine if the reorganization resulted in a more effective and more efficient flight line organization. The literature on productivity and productivity measurement in the civilian world, as well as in the Air Force maintenance, was reviewed. Forty eight months worth of maintenance data from the 552d Air Control Wing was obtained, and then analyzed, in order to answer seven research questions. The answers to the research questions indicated that the aircraft generation squadron concept adopted by the 552d Air Control Wing had not resulted in a more efficient and more effective flight line maintenance organization. Several areas for further research were also suggested to continue and expand the research presented here.

APPENDIX A: Glossary of Acronyms

AA	Air Abort Rate
AACS	Airborne Air Control Squadron
ACC	Air Combat Command
ACW	Air Control Wing
AFSC	Air Force Specialty Code
AGS	Aircraft Generation Squadron
AHUT	Actual Hourly Utilization Rate
AOR	Area of Responsibility
ASE	Adjusted Aircraft Scheduling Effectiveness Rate
ASUT	Actual Sortie Utilization Rate
AWACS	Airborne Warning and Control System
BRK	Break Rate
CAMS	Core Automated Maintenance System
CANN	Cannibalization Rate
CLT	Controllable Late Take-Offs Rate
DD	Delayed Discrepancy Rate
DoD	Department of Defense
FIX	Fix Rate
FSMU	Flying Squadron Maintenance Unit
GA	Ground Abort Rate
IDA	Institute for Defense Analysis
LG	Logistics (or Logistics Group)
MAC	Military Airlift Command
MC	Mission Capable Rate
MCX	Maintenance Cancellation Rate
MEFF	Maintenance Effectiveness Rate
MFH	Man-hours per Flying Hour
NCO	Non-Commissioned Officer
NMCM	Total Not Mission Capable For Maintenance Rate
NMCS	Total Not Mission Capable For Supply Rate
OG	Operations Group
PHUT	Planned Hourly Utilization Rate
POSS	Average Possessed Aircraft
PSUT	Planned Sortie Utilization Rate
REC	Recur Rate
REMIS	Reliability and Maintainability Information System
REP	Repeat Rate
SAC	Strategic Air Command
TAC	Tactical Air Command

APPENDIX B: Data Set

No.	Month	Year	Group	POSS	MC	NMCM	NMCS	ASE
1	Dec	1993	Pre	14.1	92.5	4.1	3.6	86.6
2	Jan	1994	Pre	14.7	86.2	6.8	8.7	89.5
3	Feb	1994	Pre	13.3	86.7	8.8	5.2	93.0
4	Mar	1994	Pre	13.9	89.7	7.0	4.2	87.5
5	Apr	1994	Pre	13.3	89.2	6.3	4.6	94.4
6	May	1994	Pre	12.8	80.1	13.6	8.0	80.2
7	Jun	1994	Pre	13.5	89.0	7.1	4.1	91.6
8	Jul	1994	Pre	14.1	87.4	9.8	3.0	90.5
9	Aug	1994	Pre	15.2	87.8	8.6	4.3	87.8
10	Sep	1994	Pre	14.4	83.3	12.9	6.8	96.5
11	Oct	1994	Pre	17.0	88.9	8.2	3.5	88.2
12	Nov	1994	Pre	16.1	87.4	10.8	3.8	89.3
13	Dec	1994	Pre	15.9	84.0	11.7	6.6	79.7
14	Jan	1995	Pre	17.2	88.4	9.8	2.3	77.7
15	Feb	1995	Pre	18.0	85.8	12.0	4.5	86.3
16	Mar	1995	Pre	16.6	85.4	10.7	6.9	95.2
17	Apr	1995	Pre	16.9	87.4	9.4	3.3	93.7
18	May	1995	Pre	16.5	85.1	11.3	4.7	89.2
19	Jun	1995	Pre	17.4	85.7	11.1	4.3	94.1
20	Jul	1995	Pre	17.0	80.9	14.3	7.9	95.0
21	Aug	1995	Pre	16.2	82.7	13.5	6.7	86.8
22	Sep	1995	Pre	16.1	89.7	9.2	1.8	91.5
23	Oct	1995	Pre	15.4	84.9	13.0	4.8	81.9
24	Nov	1995	Pre	15.8	80.3	13.1	8.5	91.4

No.	Month	Year	Group	CLT	GA	AA	MCX	CANN
1	Dec	1993	Pre	5.4	4.3	2.7	0.0	13.6
2	Jan	1994	Pre	4.8	0.8	1.6	0.8	21.1
3	Feb	1994	Pre	4.0	1.0	6.1	1.0	31.6
4	Mar	1994	Pre	3.9	2.0	2.0	2.0	21.1
5	Apr	1994	Pre	1.6	0.0	1.6	1.6	13.8
6	May	1994	Pre	12.5	3.1	1.1	0.0	34.7
7	Jun	1994	Pre	6.7	0.8	1.7	0.0	21.0
8	Jul	1994	Pre	3.2	2.0	1.0	1.1	28.1
9	Aug	1994	Pre	6.5	3.5	3.7	0.0	19.1
10	Sep	1994	Pre	2.4	1.2	0.0	0.0	47.6
11	Oct	1994	Pre	6.6	1.3	2.6	0.0	26.3
12	Nov	1994	Pre	8.2	0.0	3.2	0.0	13.4
13	Dec	1994	Pre	11.3	3.0	1.5	1.5	29.0
14	Jan	1995	Pre	14.9	2.6	3.3	1.4	27.3
15	Feb	1995	Pre	8.1	1.8	2.5	1.3	20.4
16	Mar	1995	Pre	2.4	1.2	1.2	1.2	23.2
17	Apr	1995	Pre	3.8	0.6	4.5	0.6	5.7
18	May	1995	Pre	8.9	1.3	3.2	1.3	12.8
19	Jun	1995	Pre	1.6	1.6	2.2	0.5	15.8
20	Jul	1995	Pre	3.1	1.9	3.8	0.0	14.6
21	Aug	1995	Pre	6.3	3.5	3.6	2.1	26.3
22	Sep	1995	Pre	3.6	3.0	4.9	0.0	11.7
23	Oct	1995	Pre	11.4	2.7	2.8	1.3	16.6
24	Nov	1995	Pre	5.9	0.7	4.7	2.0	5.4

No.	Month	Year	Group	BRK	FIX	REP	REC	DD
1	Dec	1993	Pre	13.6	86.7	1.4	2.4	13.3
2	Jan	1994	Pre	15.4	89.5	1.0	1.6	12.3
3	Feb	1994	Pre	18.4	61.1	1.1	0.8	14.8
4	Mar	1994	Pre	15.6	78.3	1.7	1.4	13.5
5	Apr	1994	Pre	16.3	70.0	1.4	1.2	12.2
6	May	1994	Pre	17.9	70.6	0.5	1.9	11.1
7	Jun	1994	Pre	14.3	88.2	0.2	1.0	11.5
8	Jul	1994	Pre	25.0	70.8	1.0	1.2	13.6
9	Aug	1994	Pre	21.3	86.2	0.4	1.6	11.1
10	Sep	1994	Pre	17.9	73.3	0.7	0.5	10.9
11	Oct	1994	Pre	17.8	88.9	0.5	1.4	12.5
12	Nov	1994	Pre	15.9	76.0	0.8	1.2	11.6
13	Dec	1994	Pre	26.7	60.0	1.4	1.6	12.2
14	Jan	1995	Pre	21.3	62.5	1.3	0.7	13.1
15	Feb	1995	Pre	19.8	81.3	0.6	1.7	12.0
16	Mar	1995	Pre	15.9	84.6	1.5	2.0	12.3
17	Apr	1995	Pre	23.6	70.3	1.9	2.1	13.4
18	May	1995	Pre	19.2	53.3	1.1	1.7	14.9
19	Jun	1995	Pre	15.8	72.4	1.0	0.5	13.8
20	Jul	1995	Pre	20.4	56.3	0.0	0.6	17.3
21	Aug	1995	Pre	28.5	66.7	2.1	1.2	17.9
22	Sep	1995	Pre	22.7	83.8	0.8	1.9	18.0
23	Oct	1995	Pre	19.3	82.1	1.8	1.4	17.6
24	Nov	1995	Pre	27.0	85.0	0.7	1.2	20.1

No.	Month	Year	Group	PHUT	PSUT	AHUT	ASUT	MEFF
1	Dec	1993	Pre	46.6	7.2	53.2	7.8	98.1
2	Jan	1994	Pre	41.5	6.8	49.0	8.4	100.0
3	Feb	1994	Pre	38.0	6.3	44.1	7.4	99.4
4	Mar	1994	Pre	60.9	9.4	67.1	10.6	99.3
5	Apr	1994	Pre	52.7	8.7	54.6	9.2	98.7
6	May	1994	Pre	59.0	8.2	53.2	7.4	96.1
7	Jun	1994	Pre	65.4	9.3	59.4	8.8	97.6
8	Jul	1994	Pre	40.1	6.1	44.7	6.8	99.1
9	Aug	1994	Pre	50.7	8.1	53.2	9.0	97.3
10	Sep	1994	Pre	39.7	5.2	52.6	5.8	98.8
11	Oct	1994	Pre	48.8	8.6	50.9	8.9	100.0
12	Nov	1994	Pre	60.6	9.7	60.6	9.7	98.7
13	Dec	1994	Pre	46.5	7.5	51.9	8.2	97.6
14	Jan	1995	Pre	49.4	7.9	52.9	8.7	98.4
15	Feb	1995	Pre	52.1	8.6	57.4	9.0	100.0
16	Mar	1995	Pre	39.8	9.4	59.5	9.9	97.0
17	Apr	1995	Pre	47.6	7.6	54.3	9.3	100.0
18	May	1995	Pre	61.4	9.0	61.0	9.4	98.3
19	Jun	1995	Pre	56.6	7.9	58.9	10.6	95.8
20	Jul	1995	Pre	51.8	8.7	52.9	9.2	98.8
21	Aug	1995	Pre	59.1	9.1	53.4	8.5	100.0
22	Sep	1995	Pre	49.6	8.2	60.1	10.1	100.0
23	Oct	1995	Pre	43.6	6.1	60.3	9.4	100.0
24	Nov	1995	Pre	42.2	5.9	65.6	9.4	97.5

No.	Month	Year	Group	MFH	MC/MFH	Hr Goal	Sr Goal
1	Dec	1993	Pre	24.1	3.8	114.16	108.33
2	Jan	1994	Pre	29.1	3	118.07	123.53
3	Feb	1994	Pre	25.4	3.4	116.05	117.46
4	Mar	1994	Pre	23.6	3.8	110.18	112.77
5	Apr	1994	Pre	27.8	3.2	103.61	105.75
6	May	1994	Pre	27.2	2.9	90.17	90.24
7	Jun	1994	Pre	21.3	4.2	90.83	94.62
8	Jul	1994	Pre	30.8	2.8	111.47	111.48
9	Aug	1994	Pre	27.5	3.2	104.93	111.11
10	Sep	1994	Pre	22.8	3.7	132.49	111.54
11	Oct	1994	Pre	10.2	8.7	104.3	103.49
12	Nov	1994	Pre	21.4	4.1	100	100
13	Dec	1994	Pre	23.4	3.6	111.61	109.33
14	Jan	1995	Pre	24.5	3.6	107.09	110.13
15	Feb	1995	Pre	24.6	3.5	110.17	104.65
16	Mar	1995	Pre	22.5	3.8	149.5	105.32
17	Apr	1995	Pre	21.7	4	114.08	122.37
18	May	1995	Pre	19.6	4.3	99.35	104.44
19	Jun	1995	Pre	24.9	3.4	104.06	134.18
20	Jul	1995	Pre	25.1	3.2	102.12	105.75
21	Aug	1995	Pre	23.2	3.6	90.36	93.41
22	Sep	1995	Pre	15.5	5.8	121.17	123.17
23	Oct	1995	Pre	18.3	4.6	138.3	154.1
24	Nov	1995	Pre	12.6	6.4	155.45	159.32

No.	Month	Year	Group	POSS	MC	NMCM	NMCS	ASE
1	Jan	1996	Post	17.7	83.3	13.6	5.8	87.0
2	Feb	1996	Post	17.8	83.0	14.5	5.8	75.9
3	Mar	1996	Post	17.3	80.8	14.4	8.2	72.8
4	Apr	1996	Post	17.0	80.1	17.2	8.5	60.5
5	May	1996	Post	17.6	80.5	17.0	5.8	64.2
6	Jun	1996	Post	17.4	83.1	13.5	5.8	67.5
7	Jul	1996	Post	17.3	79.1	16.3	6.5	54.3
8	Aug	1996	Post	17.0	75.7	18.9	8.3	54.1
9	Sep	1996	Post	15.2	76.4	17.4	11.4	61.9
10	Oct	1996	Post	16.0	68.4	21.0	15.2	58.6
11	Nov	1996	Post	15.8	69.8	20.6	14.8	56.2
12	Dec	1996	Post	15.0	75.1	19.9	6.5	56.0
13	Jan	1997	Post	16.0	77.2	16.2	9.3	53.6
14	Feb	1997	Post	16.4	78.6	16.4	9.1	54.2
15	Mar	1997	Post	16.0	81.1	17.1	4.2	69.6
16	Apr	1997	Post	16.7	81.4	15.7	5.0	54.9
17	May	1997	Post	16.4	79.3	17.3	5.4	61.3
18	Jun	1997	Post	15.6	83.3	13.8	5.5	71.3
19	Jul	1997	Post	16.0	77.0	19.2	6.0	66.9
20	Aug	1997	Post	16.8	86.3	12.7	2.1	71.1
21	Sep	1997	Post	16.1	78.4	18.2	8.7	51.8
22	Oct	1997	Post	16.4	69.7	25.8	14.0	49.7
23	Nov	1997	Post	15.5	62.4	30.0	14.1	47.7
24	Dec	1997	Post	14.9	69.5	26.3	10.9	49.2

No.	Month	Year	Group	CLT	GA	AA	MCX	CANN
1	Jan	1996	Post	8.1	1.6	3.8	1.1	4.9
2	Feb	1996	Post	7.3	3.5	4.1	3.7	8.3
3	Mar	1996	Post	10.4	1.0	4.5	2.0	13.5
4	Apr	1996	Post	6.7	3.1	3.7	8.7	12.8
5	May	1996	Post	6.7	0.6	5.0	7.8	13.4
6	Jun	1996	Post	7.7	1.7	2.9	1.2	9.7
7	Jul	1996	Post	9.2	5.6	4.8	2.3	16.8
8	Aug	1996	Post	6.3	4.2	4.3	9.4	13.0
9	Sep	1996	Post	10.2	3.3	2.7	2.0	21.1
10	Oct	1996	Post	8.6	4.4	4.6	3.1	29.6
11	Nov	1996	Post	12.1	2.1	5.0	4.6	18.6
12	Dec	1996	Post	10.5	5.0	2.6	10.4	13.2
13	Jan	1997	Post	17.6	2.1	2.1	7.2	28.2
14	Feb	1997	Post	14.8	2.9	3.0	11.1	30.4
15	Mar	1997	Post	4.0	2.6	1.3	5.1	16.8
16	Apr	1997	Post	12.4	1.9	3.3	3.0	21.6
17	May	1997	Post	13.1	2.4	4.4	3.1	16.9
18	Jun	1997	Post	5.2	2.5	1.3	2.5	30.1
19	Jul	1997	Post	10.1	2.5	3.1	6.2	17.6
20	Aug	1997	Post	8.1	0.0	4.4	0.0	8.1
21	Sep	1997	Post	9.7	2.9	3.0	5.0	19.4
22	Oct	1997	Post	10.1	2.1	2.9	7.7	47.8
23	Nov	1997	Post	12.6	3.3	7.6	12.9	33.6
24	Dec	1997	Post	12.5	1.6	2.5	11.0	37.5

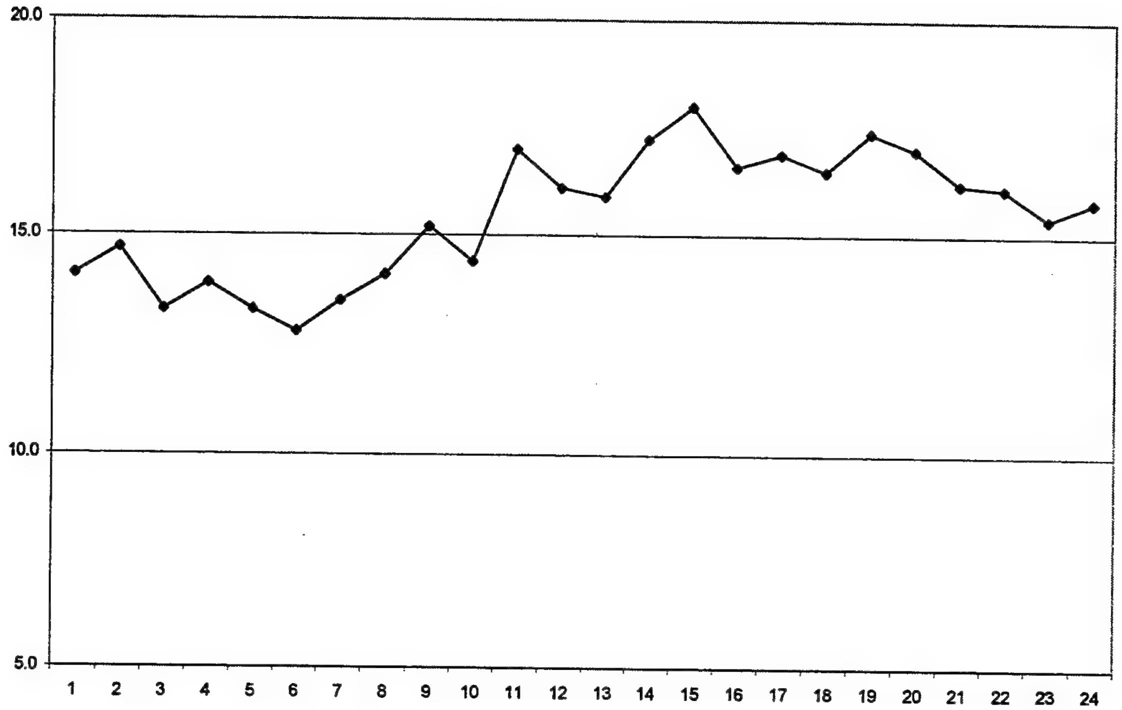
No.	Month	Year	Group	BRK	FIX	REP	REC	DD
1	Jan	1996	Post	21.9	80.0	3.8	6.6	22.3
2	Feb	1996	Post	25.9	76.0	5.1	6.0	25.2
3	Mar	1996	Post	20.5	65.9	2.3	3.1	25.6
4	Apr	1996	Post	17.0	68.8	2.5	1.8	45.4
5	May	1996	Post	26.3	72.3	1.4	4.1	27.4
6	Jun	1996	Post	22.3	61.5	1.8	0.7	26.8
7	Jul	1996	Post	25.1	64.3	0.9	2.7	22.8
8	Aug	1996	Post	34.2	63.6	2.3	1.8	24.9
9	Sep	1996	Post	30.6	86.7	1.6	2.4	24.2
10	Oct	1996	Post	28.9	70.5	1.0	1.1	24.2
11	Nov	1996	Post	25.7	63.9	0.8	0.5	20.0
12	Dec	1996	Post	29.8	67.6	1.9	2.1	20.4
13	Jan	1997	Post	35.2	74.0	2.7	2.7	20.1
14	Feb	1997	Post	24.4	66.7	2.1	2.6	23.2
15	Mar	1997	Post	26.2	59.0	2.5	1.3	21.8
16	Apr	1997	Post	25.5	53.8	0.6	2.3	19.4
17	May	1997	Post	30.6	65.3	2.7	2.5	22.9
18	Jun	1997	Post	25.5	71.8	2.2	2.4	24.0
19	Jul	1997	Post	36.5	55.2	1.6	1.6	23.6
20	Aug	1997	Post	26.3	50.0	0.8	1.9	25.5
21	Sep	1997	Post	22.4	60.0	1.6	2.1	27.1
22	Oct	1997	Post	33.3	58.7	0.5	1.2	27.4
23	Nov	1997	Post	41.2	51.0	1.6	2.1	28.9
24	Dec	1997	Post	42.5	49.0	1.8	1.1	24.9

No.	Month	Year	Group	PHUT	PSUT	AHUT	ASUT	MEFF
1	Jan	1996	Post	56.0	9.1	68.6	10.3	85.7
2	Feb	1996	Post	53.0	9.8	72.8	10.8	86.0
3	Mar	1996	Post	58.5	11.1	73.0	11.6	100.0
4	Apr	1996	Post	56.7	11.1	75.7	11.1	93.2
5	May	1996	Post	68.3	10.3	71.9	10.2	100.0
6	Jun	1996	Post	46.9	10.2	69.2	10.1	96.8
7	Jul	1996	Post	62.1	9.8	59.7	9.7	97.5
8	Aug	1996	Post	65.2	9.8	59.2	9.5	96.8
9	Sep	1996	Post	72.7	10.9	66.5	9.7	97.2
10	Oct	1996	Post	64.2	9.4	64.5	9.5	95.6
11	Nov	1996	Post	56.5	8.9	55.3	8.8	100.0
12	Dec	1996	Post	52.2	7.6	52.4	7.6	100.0
13	Jan	1997	Post	67.4	8.9	68.0	8.9	97.3
14	Feb	1997	Post	56.7	8.2	56.8	8.2	86.6
15	Mar	1997	Post	60.2	9.4	59.0	9.3	99.4
16	Apr	1997	Post	61.6	8.7	64.9	9.1	100.0
17	May	1997	Post	71.6	9.9	69.0	9.8	100.0
18	Jun	1997	Post	73.2	10.3	66.7	9.8	100.0
19	Jul	1997	Post	71.6	9.9	65.6	9.9	99.2
20	Aug	1997	Post	69.9	9.5	59.5	9.5	93.3
21	Sep	1997	Post	65.3	8.9	56.2	8.3	96.0
22	Oct	1997	Post	62.2	8.5	55.3	8.4	98.5
23	Nov	1997	Post	63.7	8.7	56.9	7.7	100.0
24	Dec	1997	Post	58.9	9.2	58.3	8.1	100.0

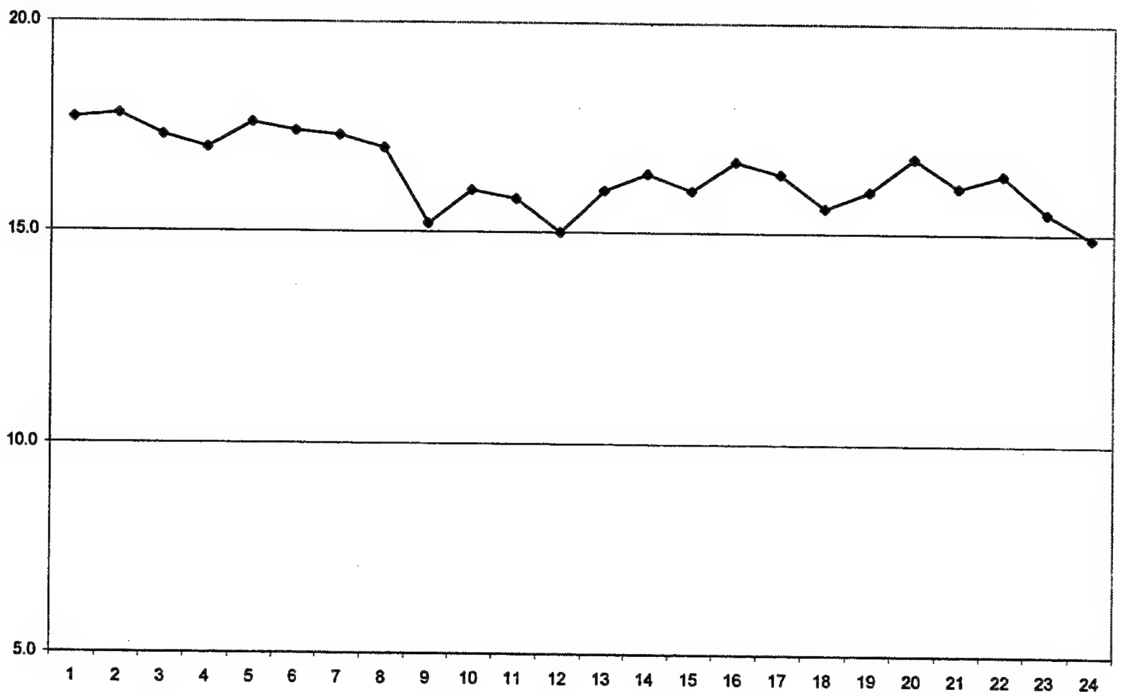
No.	Month	Year	Group	MFH	MC/MFH	Hr Goal	Sr Goal
1	Jan	1996	Post	22.8	3.7	122.5	113.19
2	Feb	1996	Post	22.4	3.7	137.36	110.2
3	Mar	1996	Post	22.2	3.6	124.79	104.5
4	Apr	1996	Post	28.4	2.8	133.51	100
5	May	1996	Post	27.5	2.9	105.27	99.03
6	Jun	1996	Post	22.1	3.8	147.55	99.02
7	Jul	1996	Post	27.0	2.9	96.14	98.98
8	Aug	1996	Post	22.6	3.3	90.8	96.94
9	Sep	1996	Post	18.2	4.2	91.47	88.99
10	Oct	1996	Post	28.4	2.4	100.47	101.06
11	Nov	1996	Post	27.5	2.5	97.88	98.88
12	Dec	1996	Post	22.1	3.4	100.38	100
13	Jan	1997	Post	27.0	2.9	100.89	100
14	Feb	1997	Post	22.6	3.5	100.18	100
15	Mar	1997	Post	33.9	2.4	98.01	98.94
16	Apr	1997	Post	23.4	3.5	105.36	104.6
17	May	1997	Post	18.4	4.3	96.37	98.99
18	Jun	1997	Post	17.1	4.9	91.12	95.15
19	Jul	1997	Post	17.2	4.5	91.62	100
20	Aug	1997	Post	17.6	4.9	85.12	100
21	Sep	1997	Post	22.1	3.5	86.06	93.26
22	Oct	1997	Post	20.4	3.4	88.91	98.82
23	Nov	1997	Post	17.6	3.5	89.32	88.51
24	Dec	1997	Post	18.0	3.9	98.98	88.04

APPENDIX C: Time Series Plots

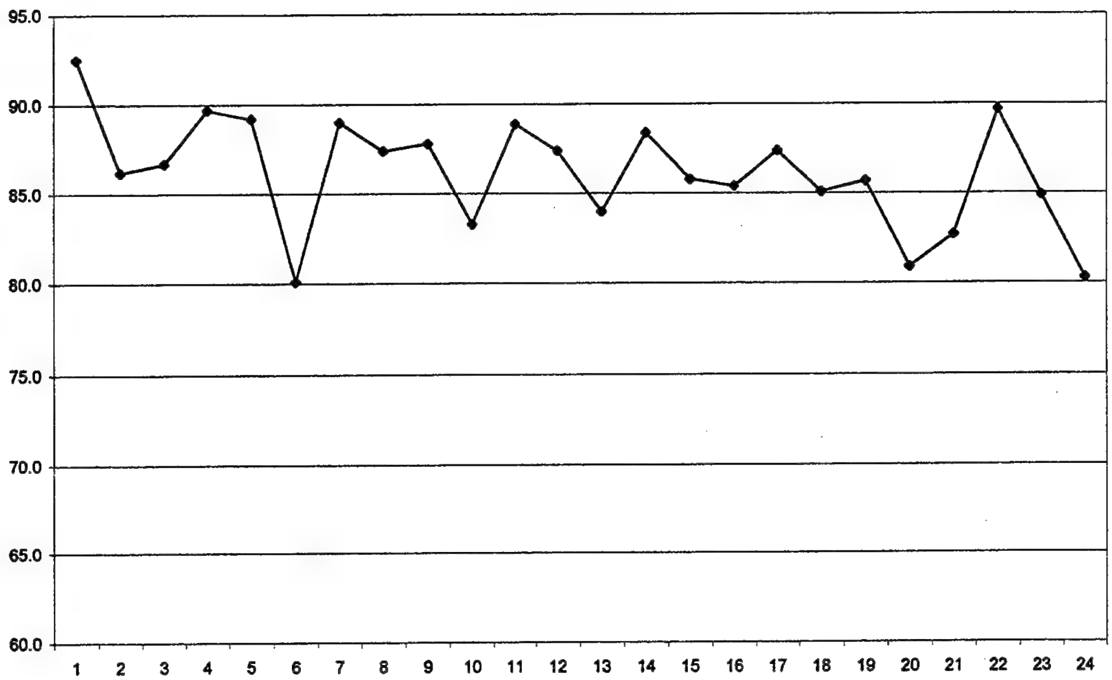
Pre Reorg POSS Rate



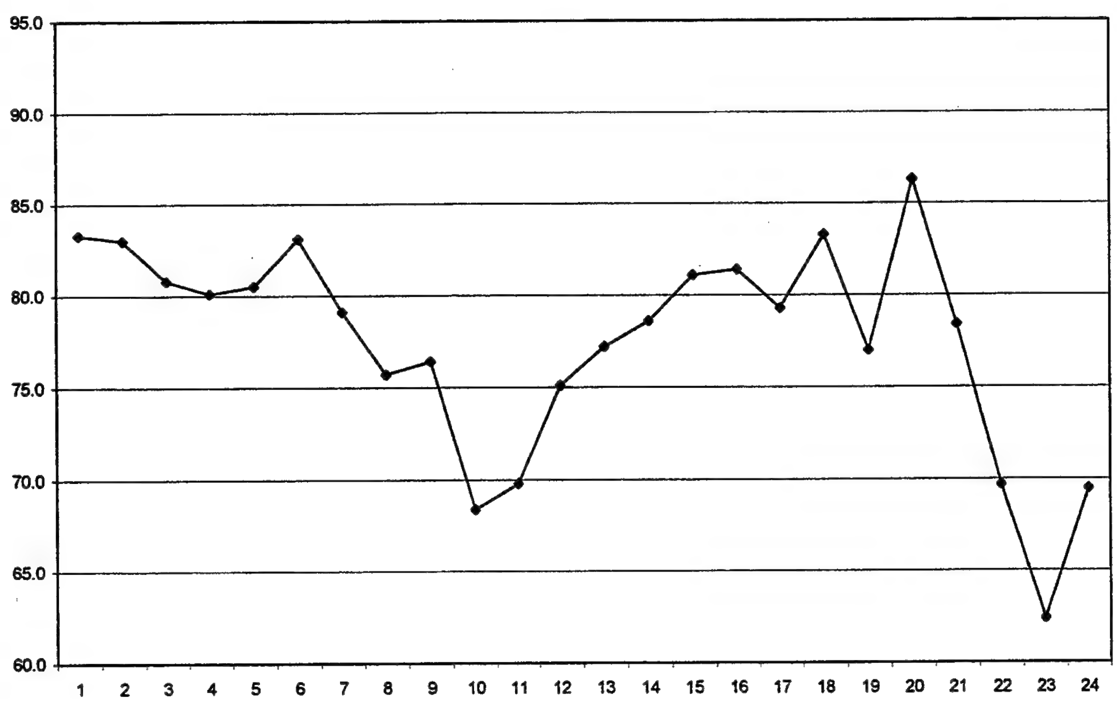
Post Reorg POSS Rate

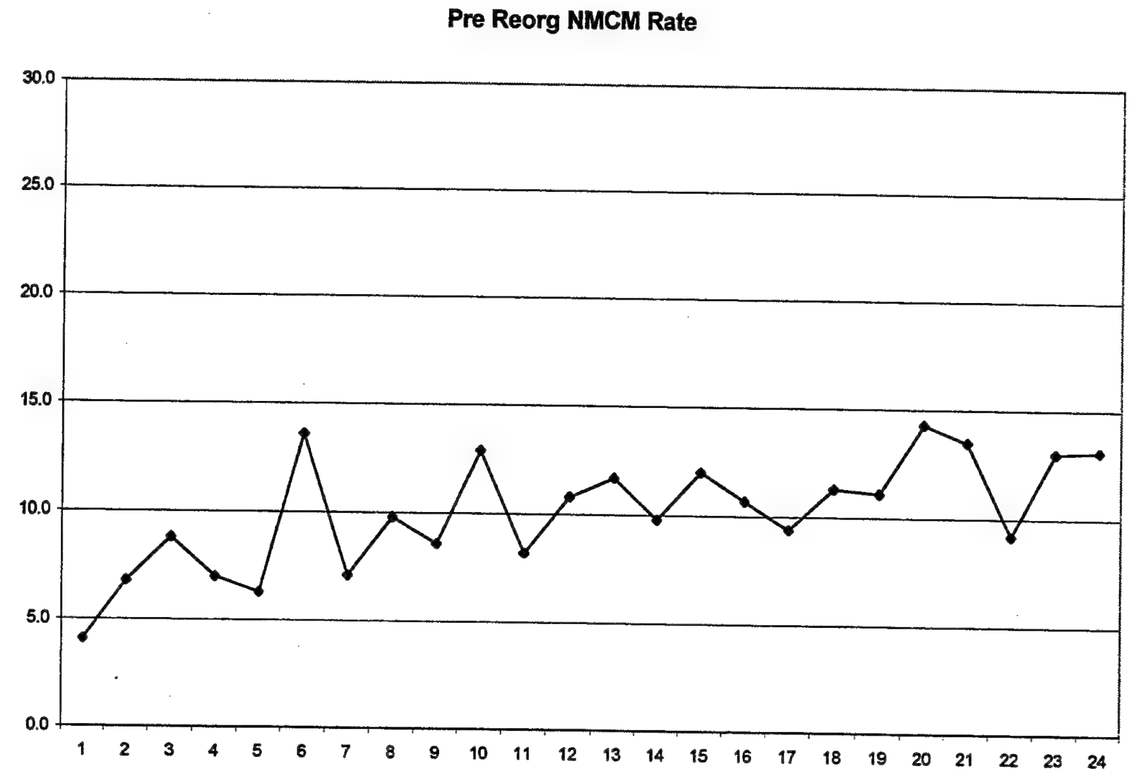


Pre Reorg MC Rate



Post Reorg MC Rate





Pre Reorg NMCM Rate
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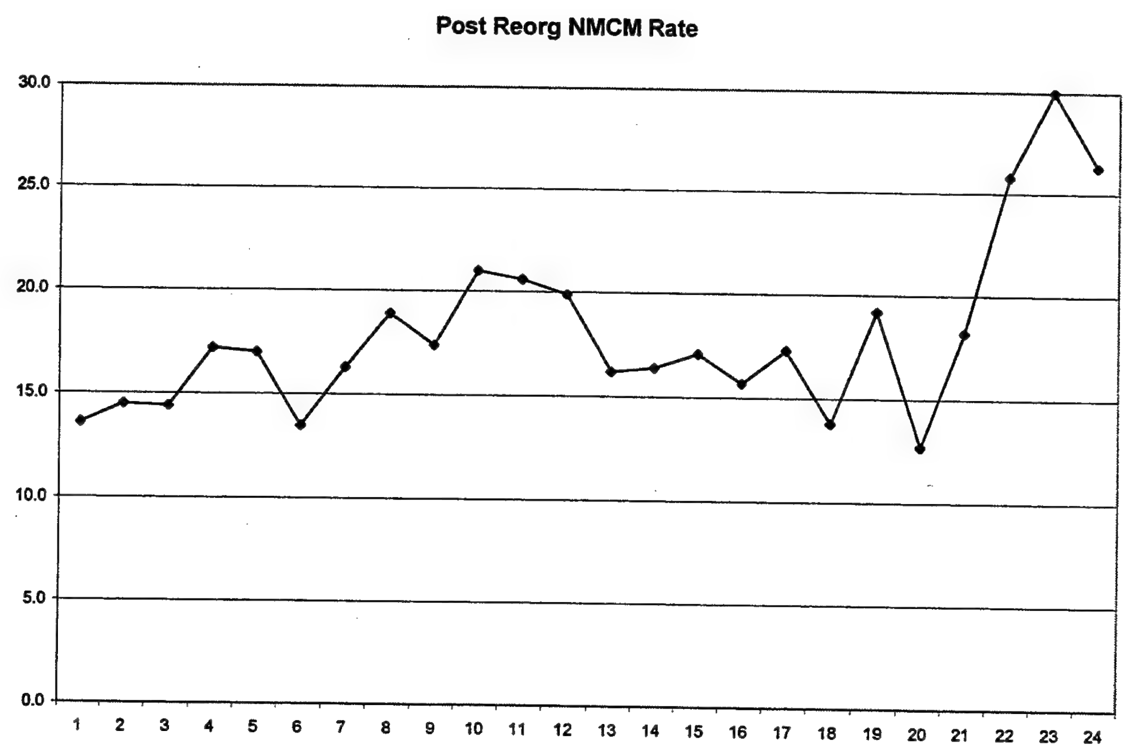
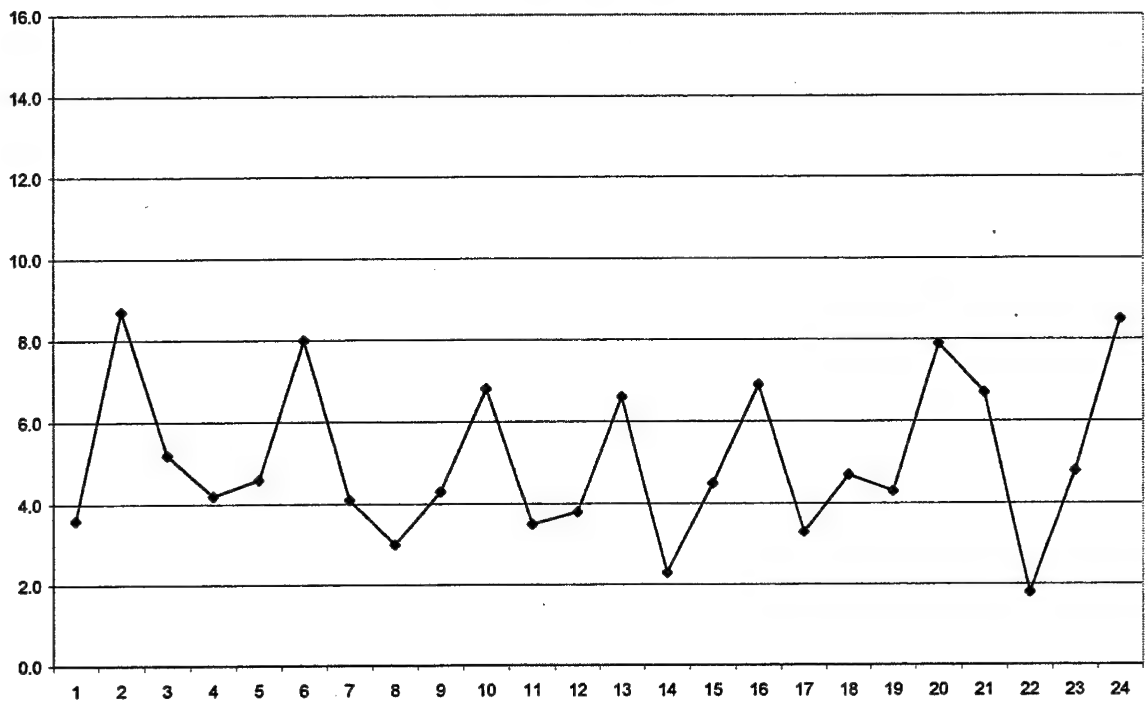
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

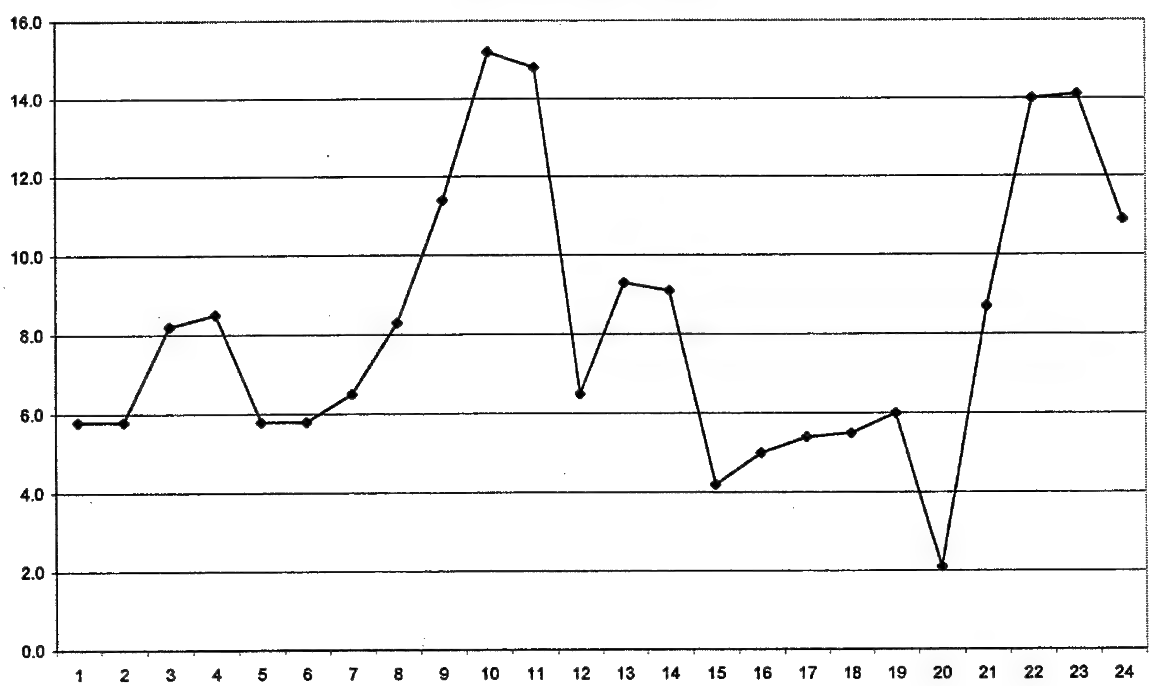


Post Reorg NMCM Rate
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

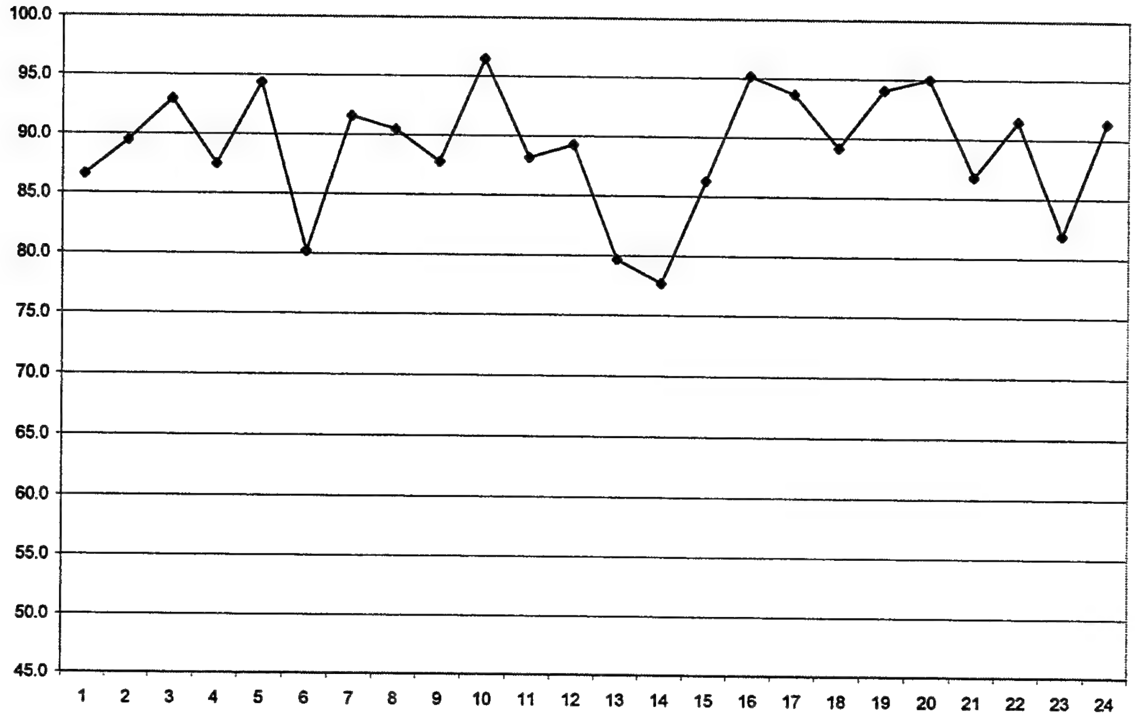
Pre Reorg NMCS Rate



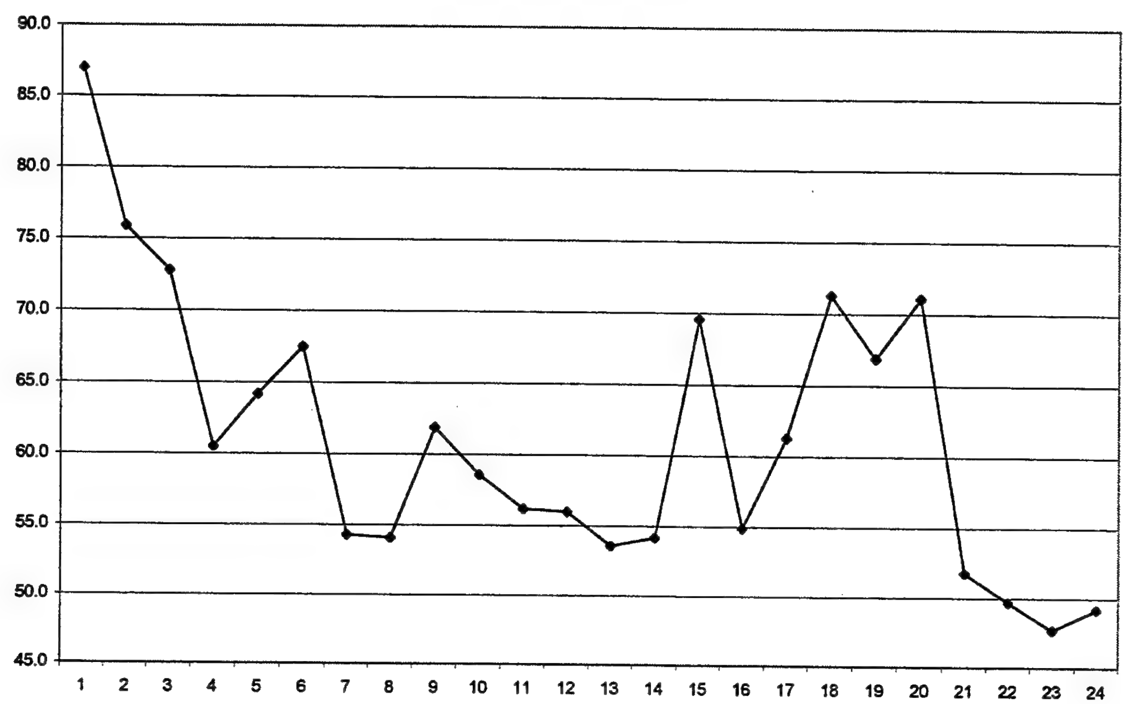
Post Reorg NMCS Rate



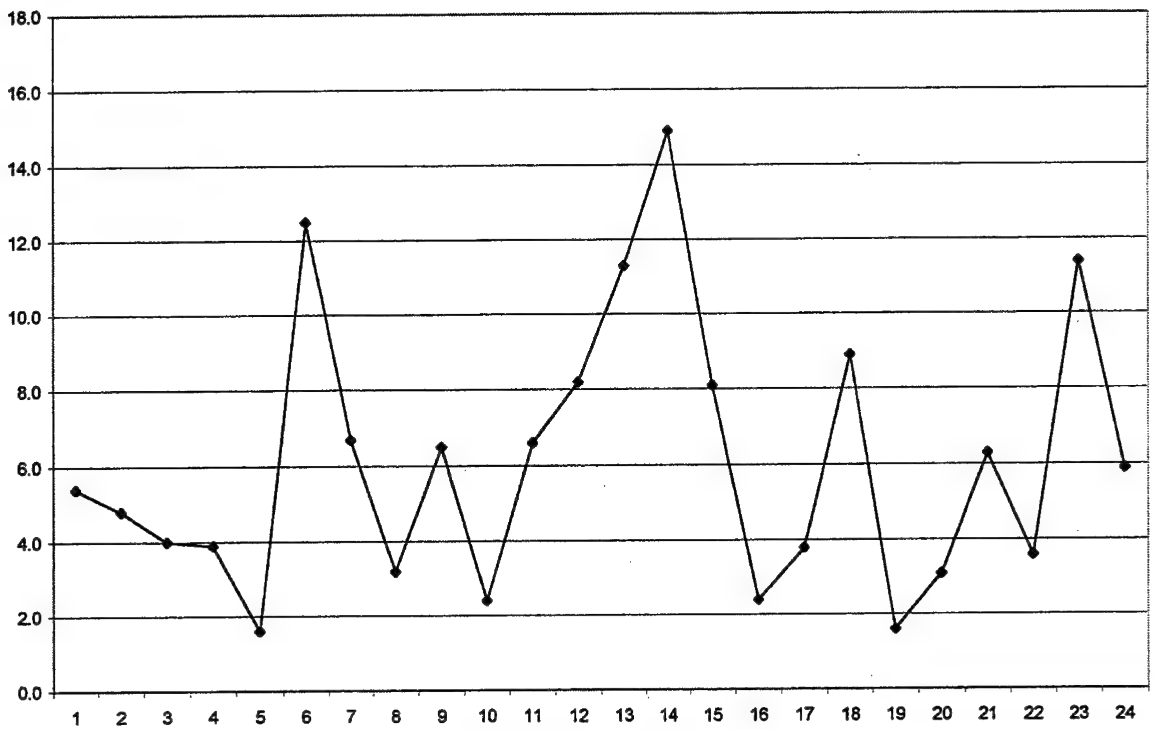
Pre Reorg ASE Rate



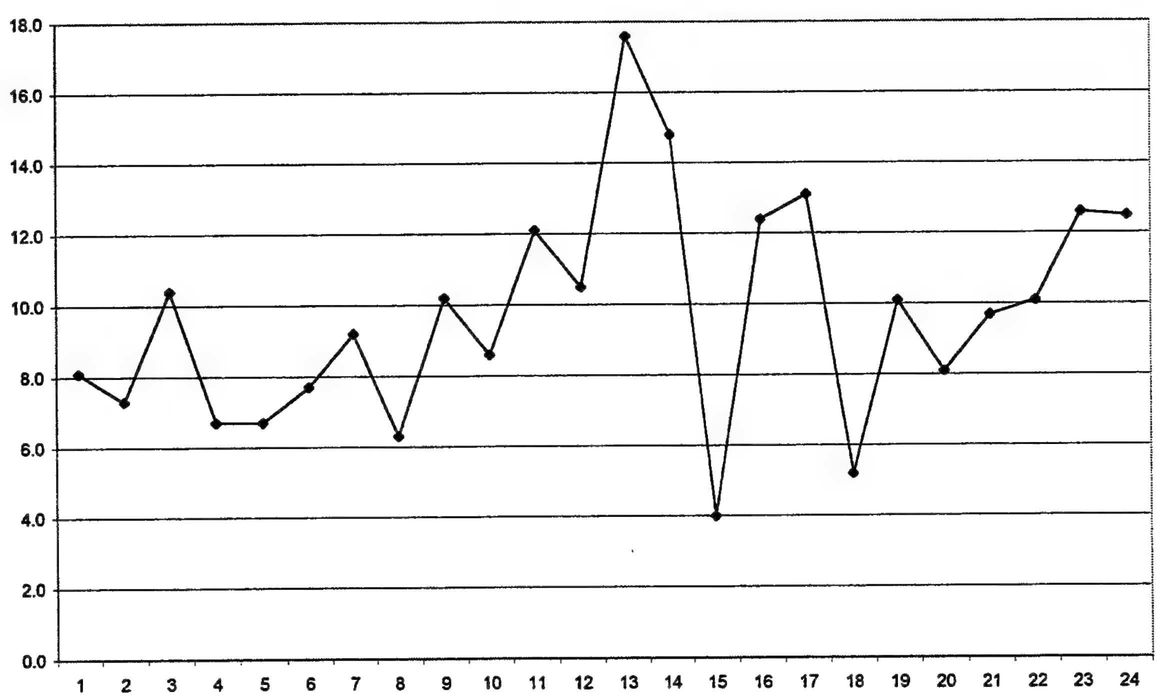
Post Reorg ASE Rate

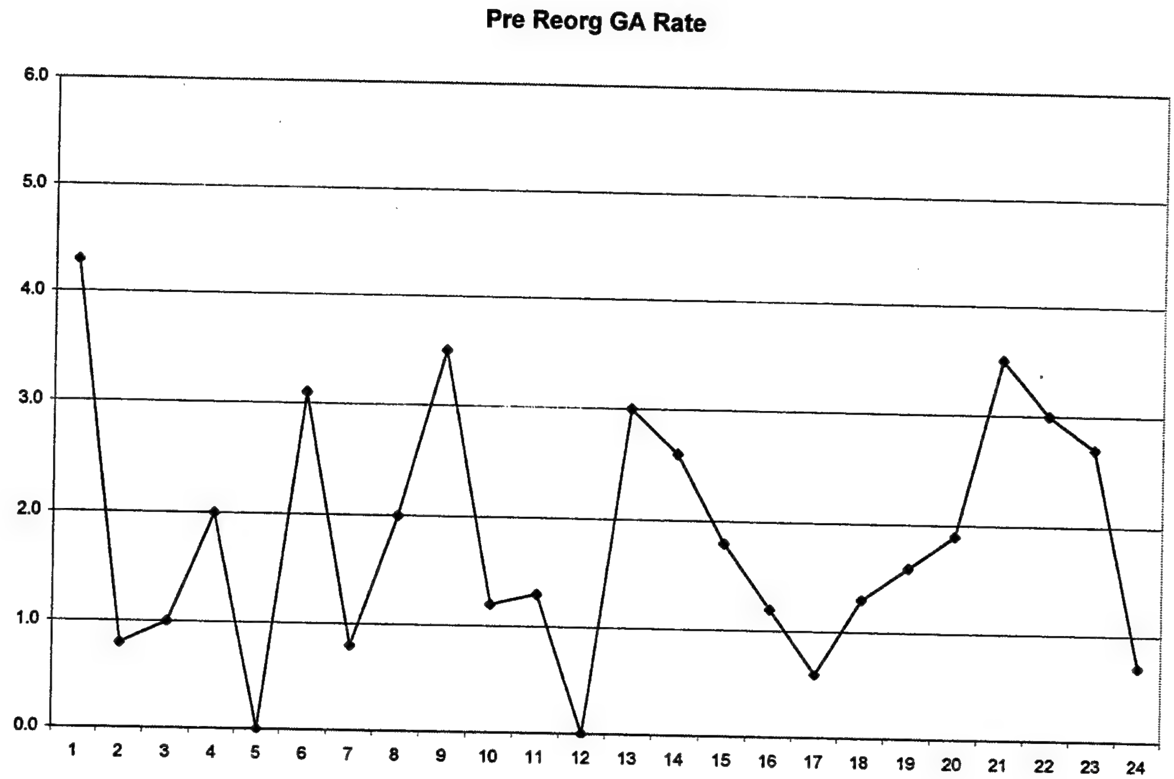


Pre Reorg CLT Rate



Post Reorg CLT Rate




Pre Reorg GA Rate
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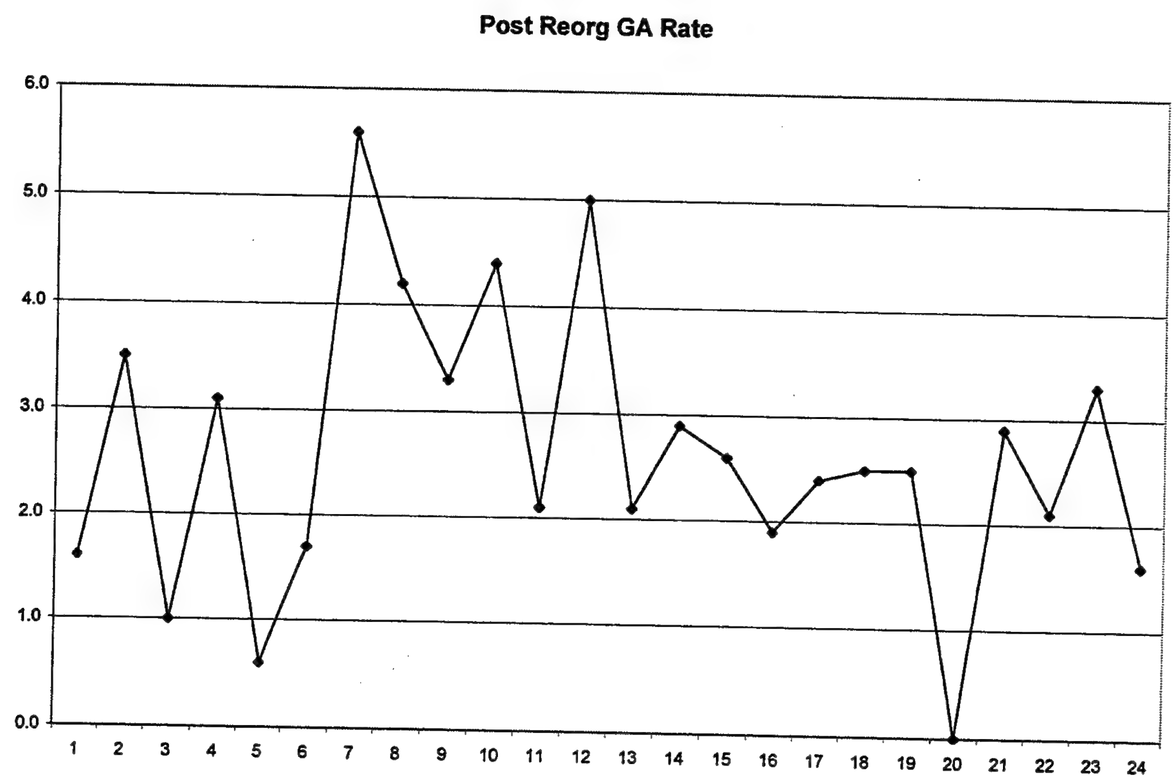
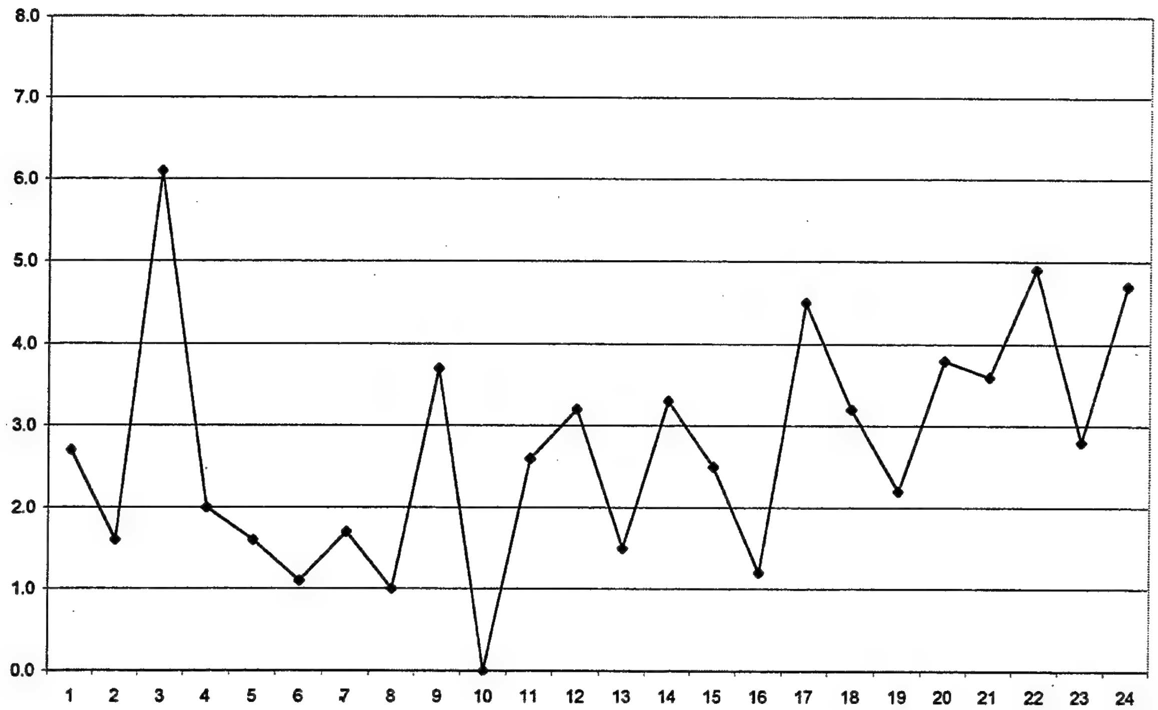
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Post Reorg GA Rate
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Pre Reorg AA Rate



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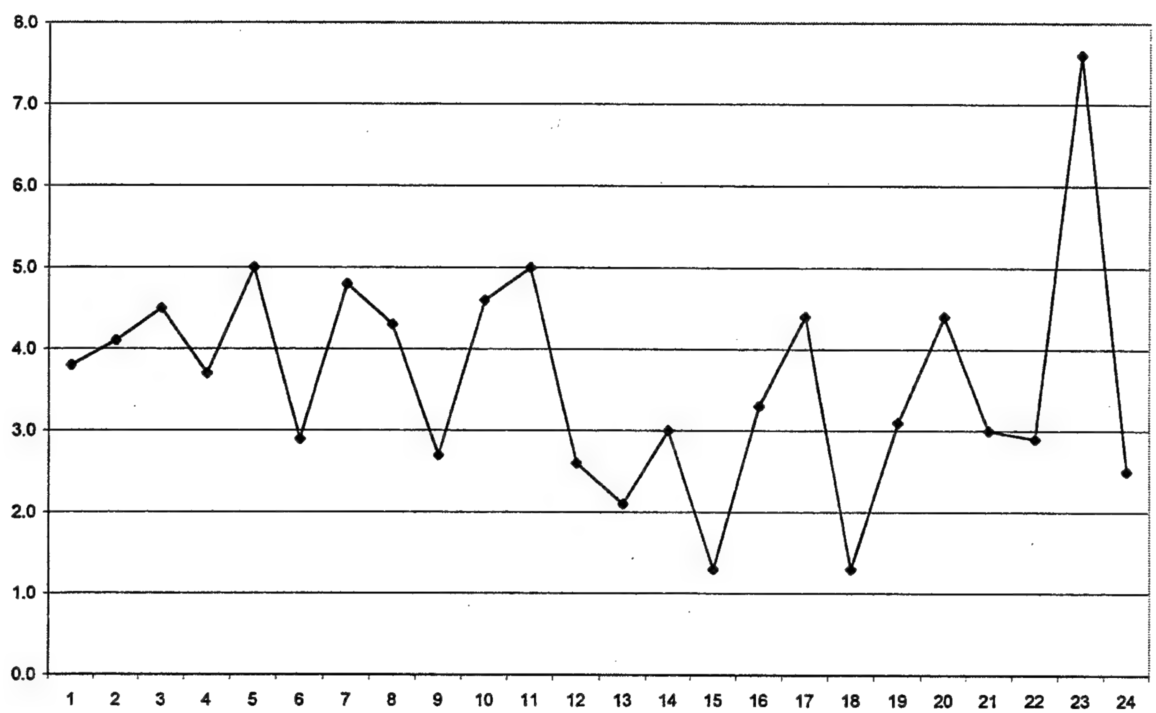
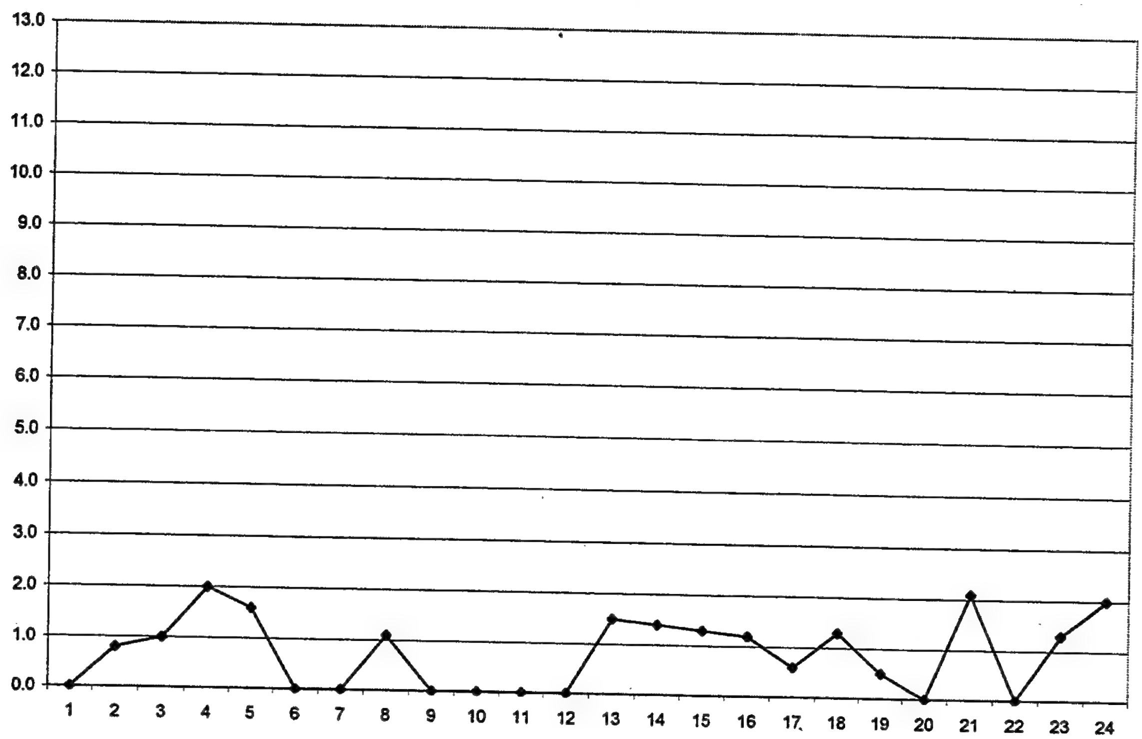
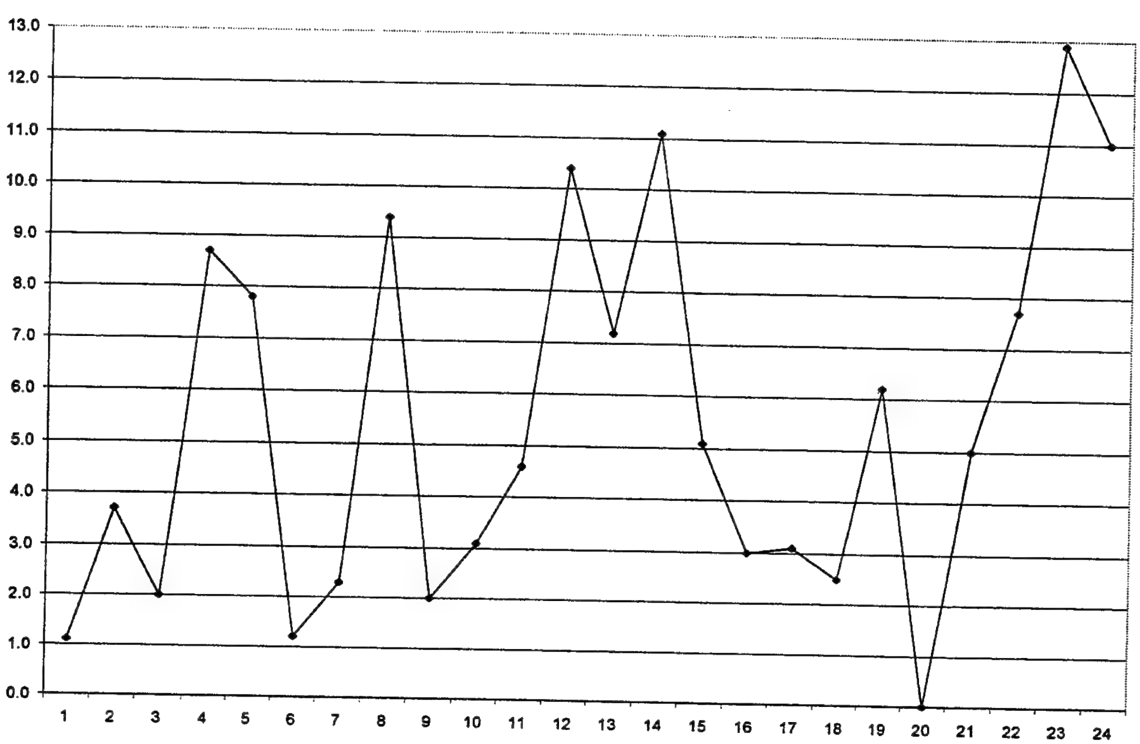


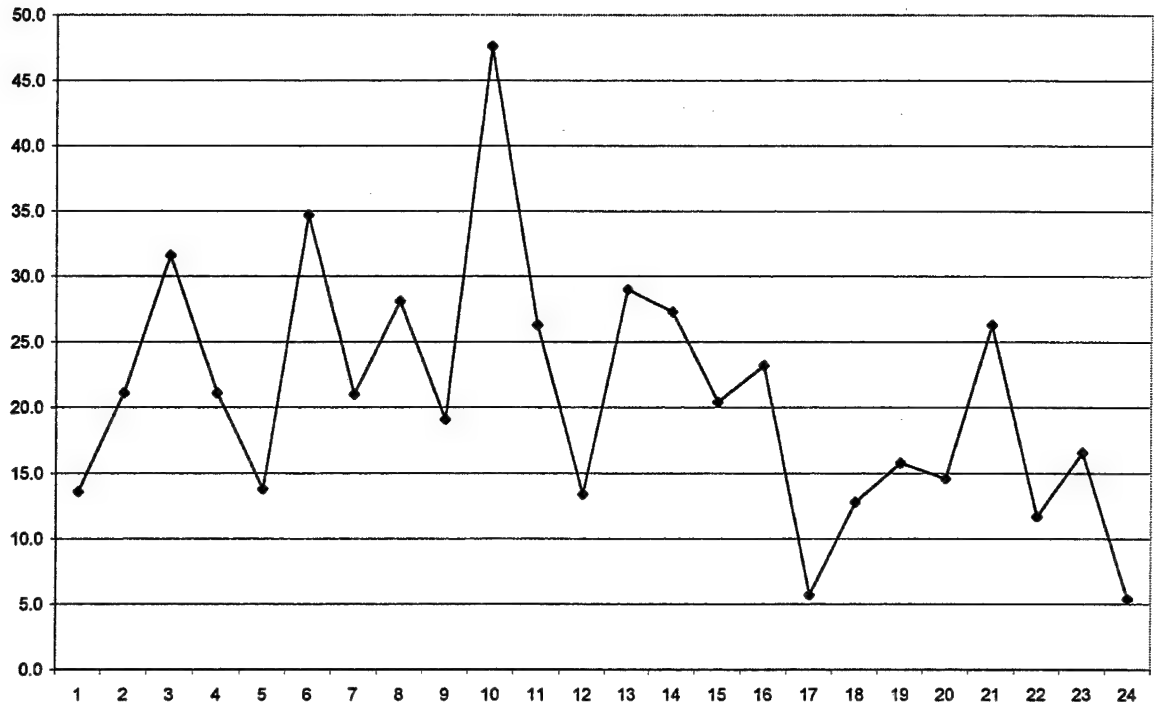
Pre Reorg MCX Rate



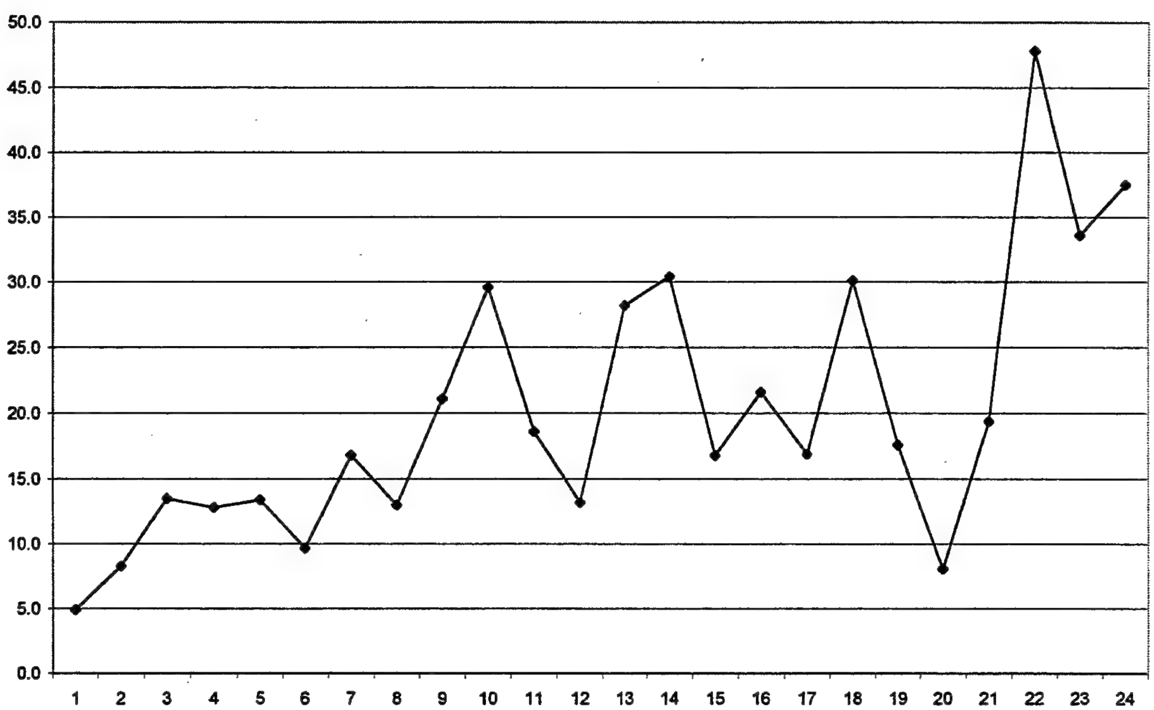
Post Reorg MCX Rate



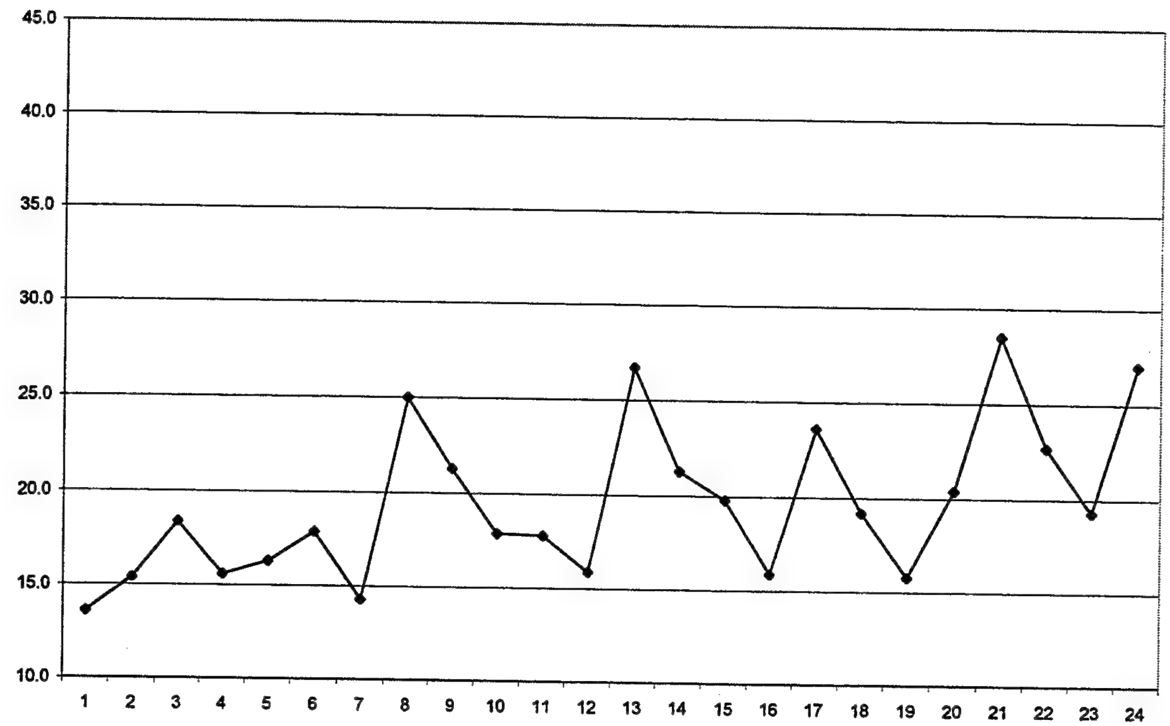
Pre Reorg CANN Rate



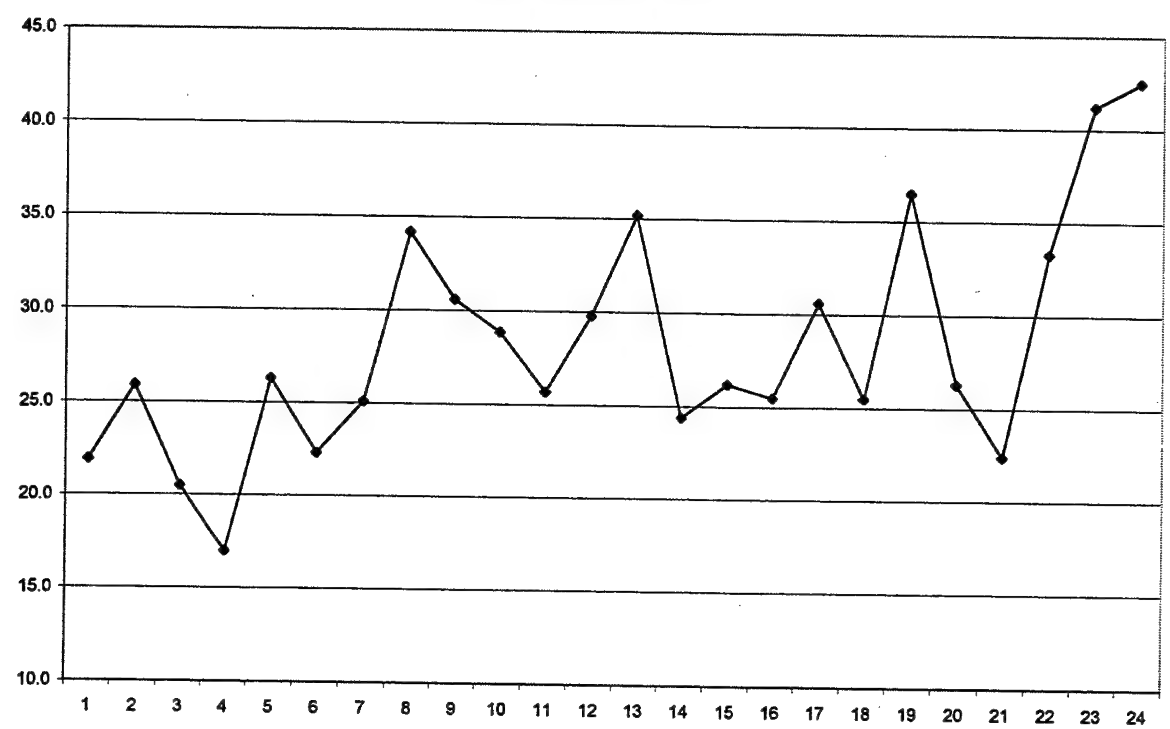
Post Reorg CANN Rate



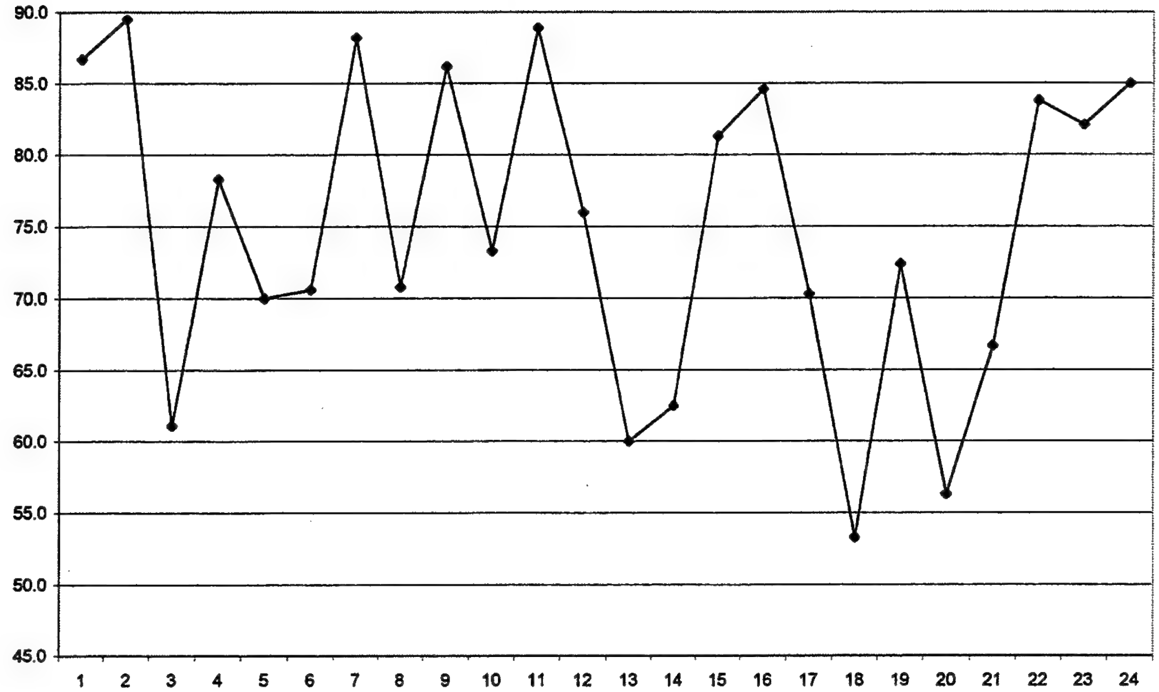
Pre Reorg BRK Rate



Post Reorg BRK Rate

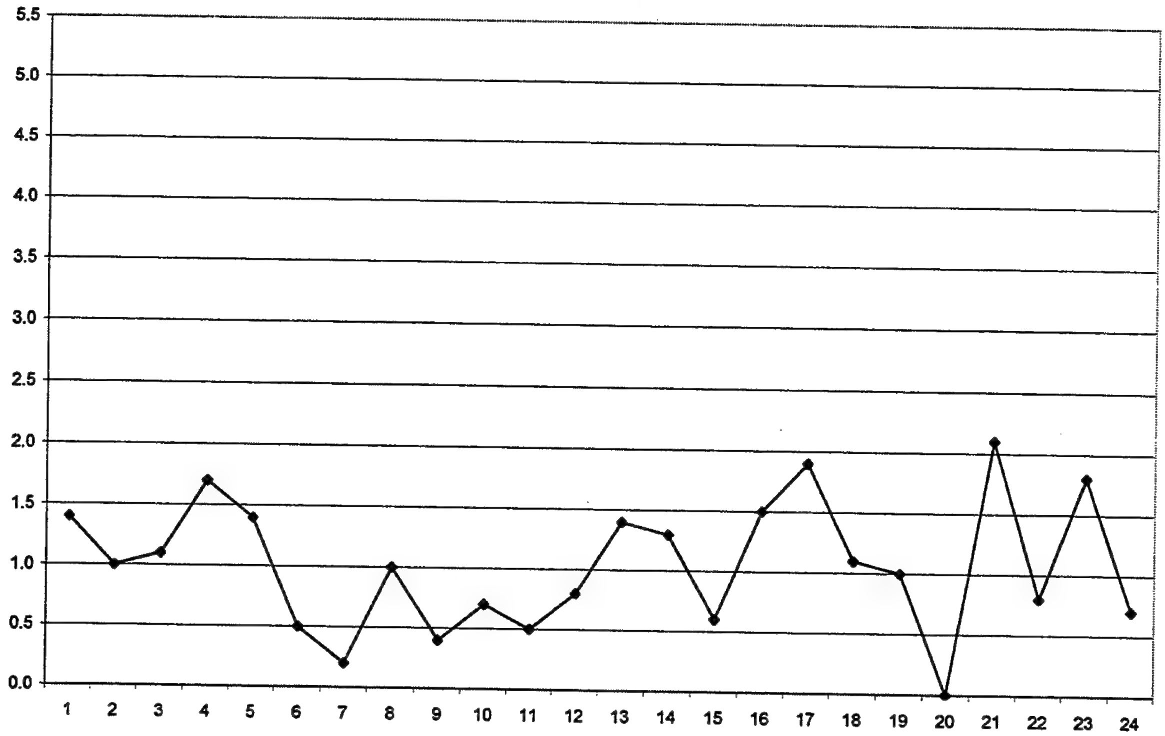


Pre Reorg FIX Rate

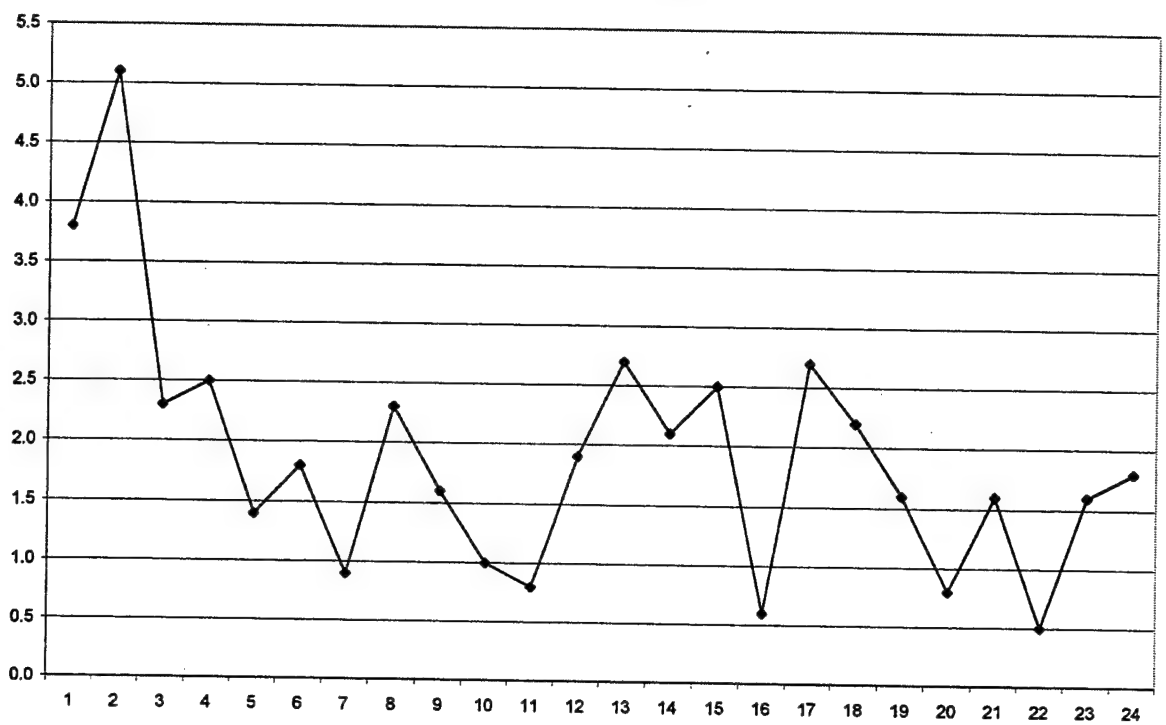


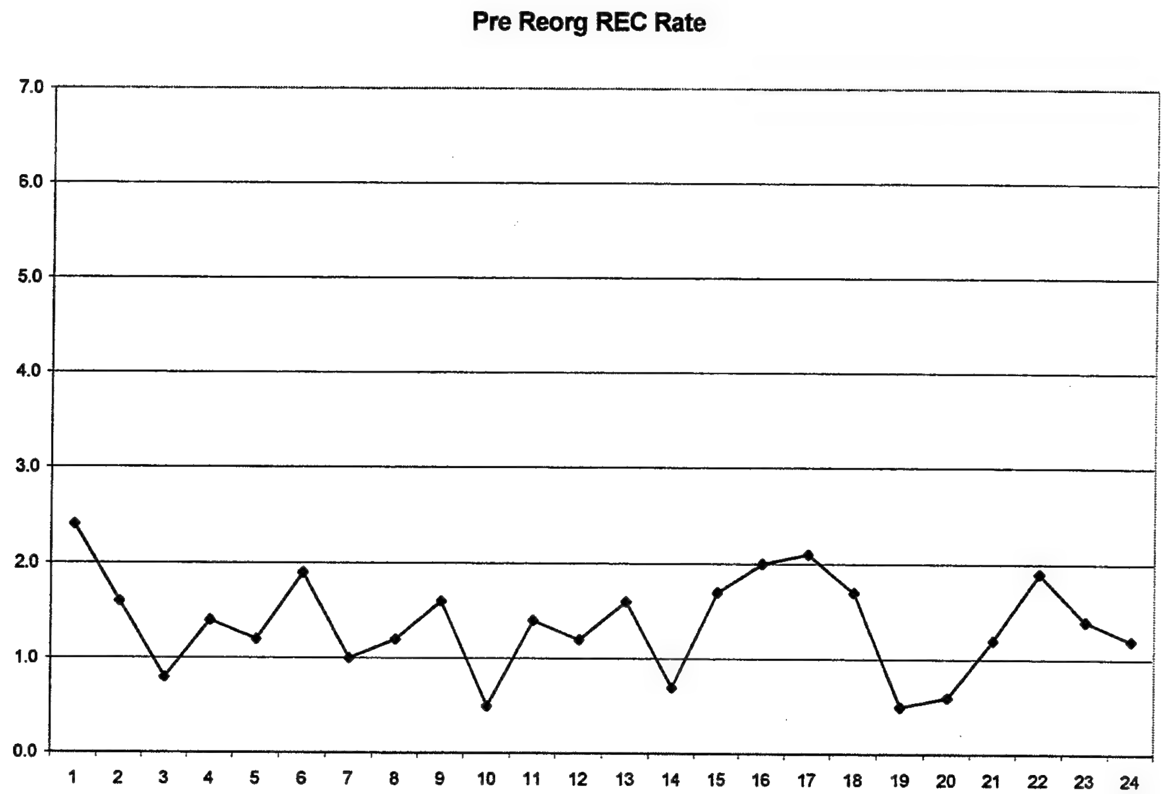
Post Reorg FIX Rate

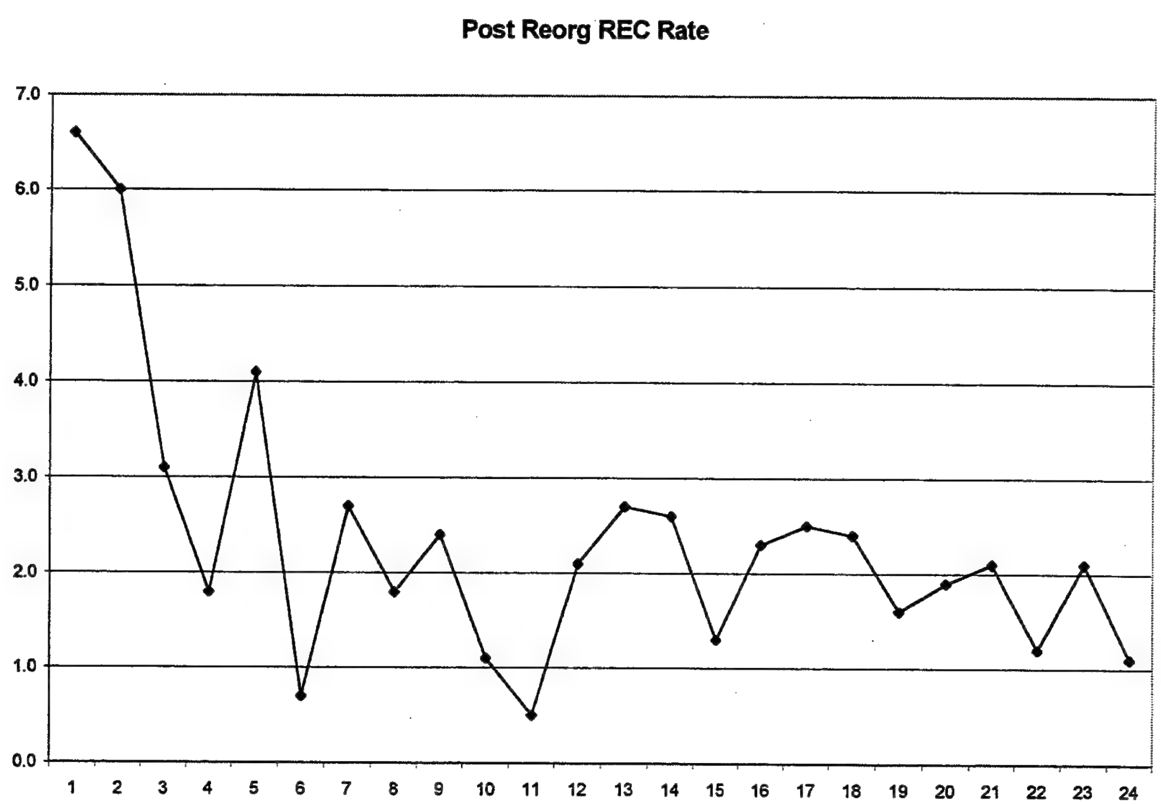
Pre Reorg REP Rate



Post Reorg REP Rate




Pre Reorg REC Rate
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Post Reorg REC Rate
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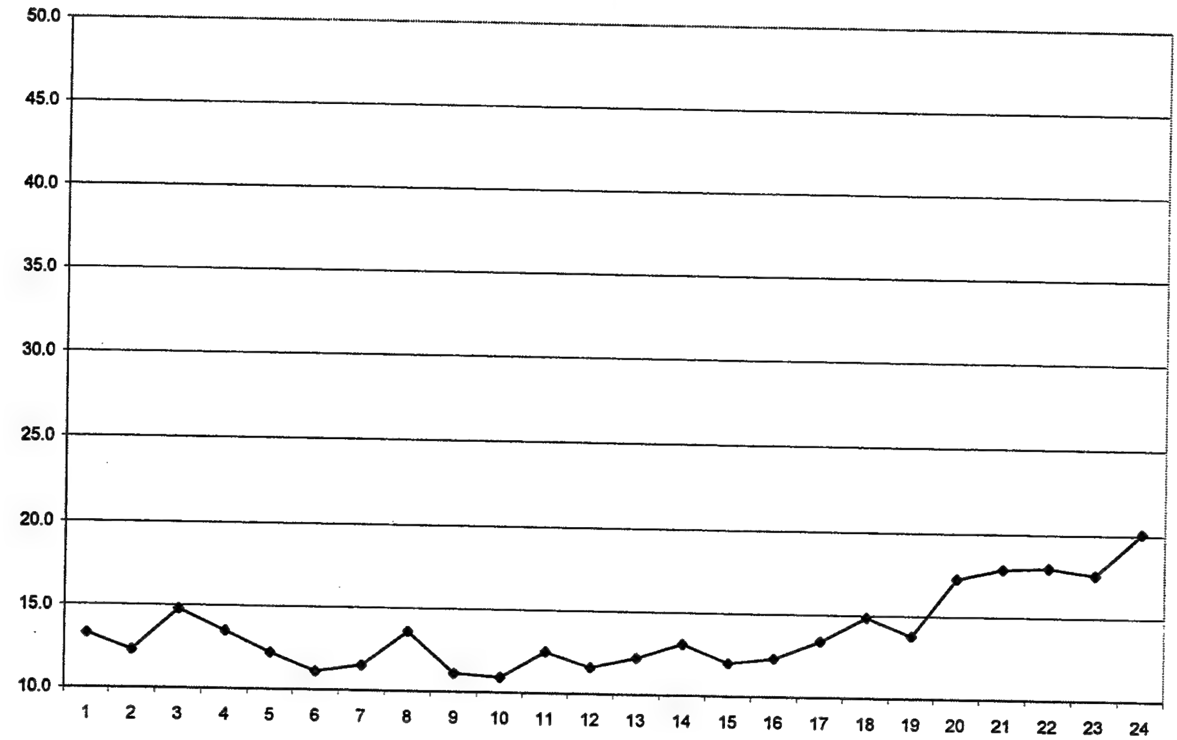
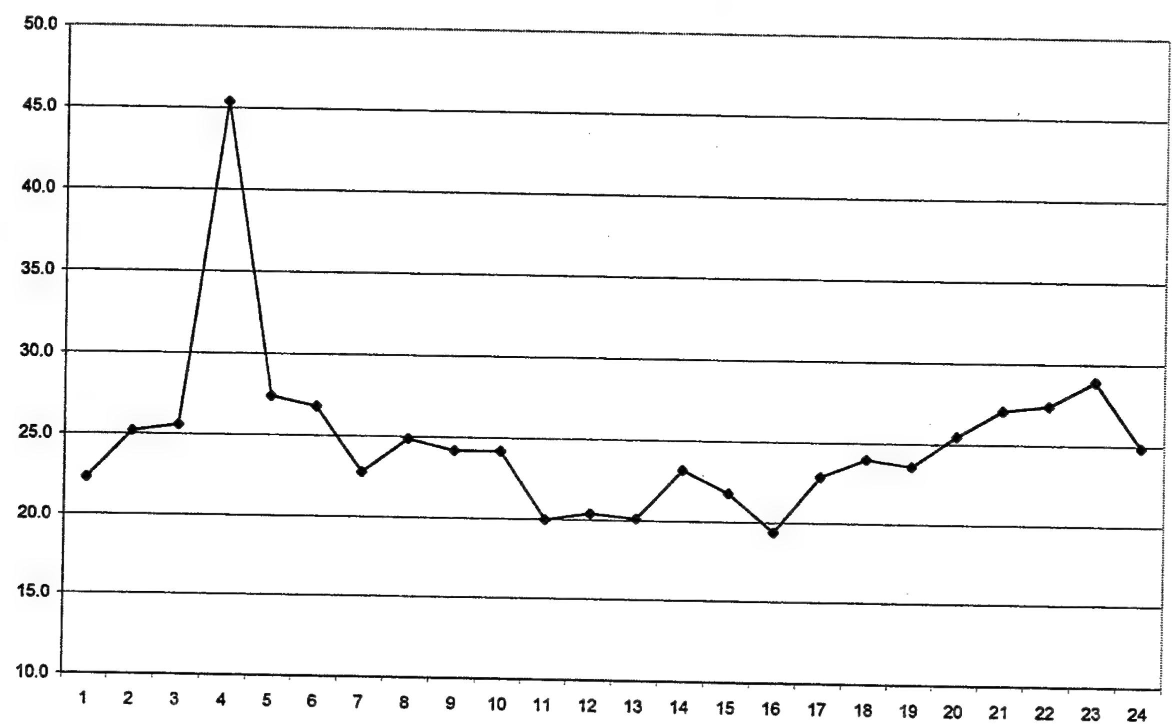
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

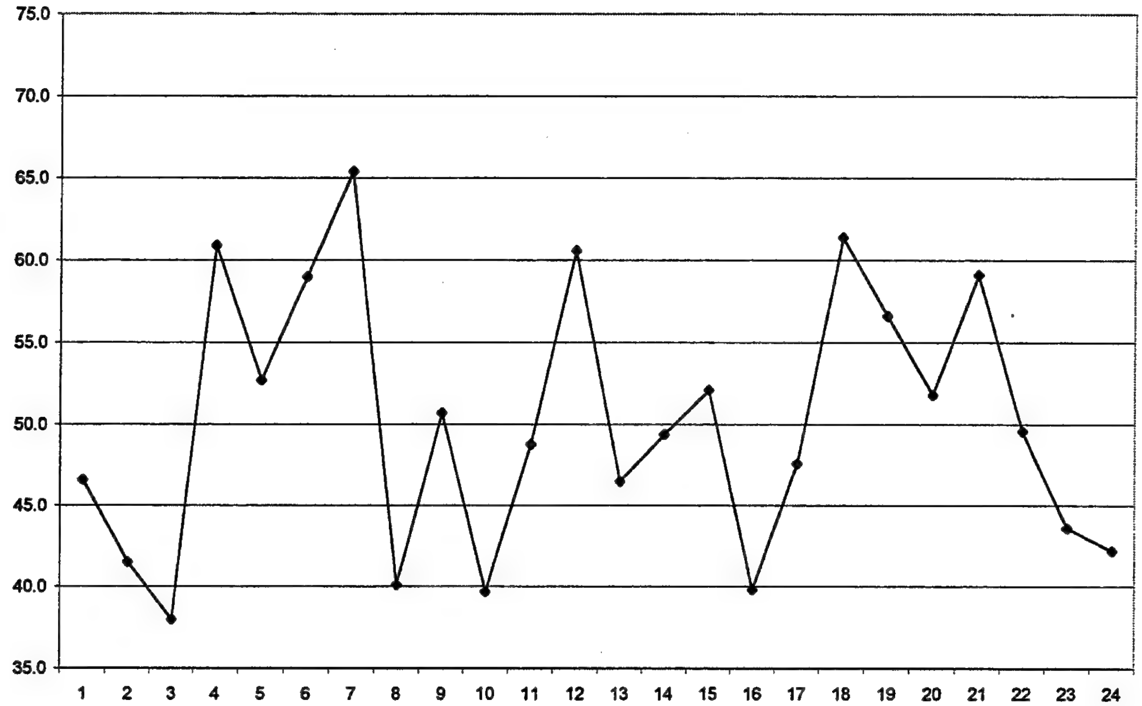
Pre Reorg DD Rate



Post Reorg DD Rate

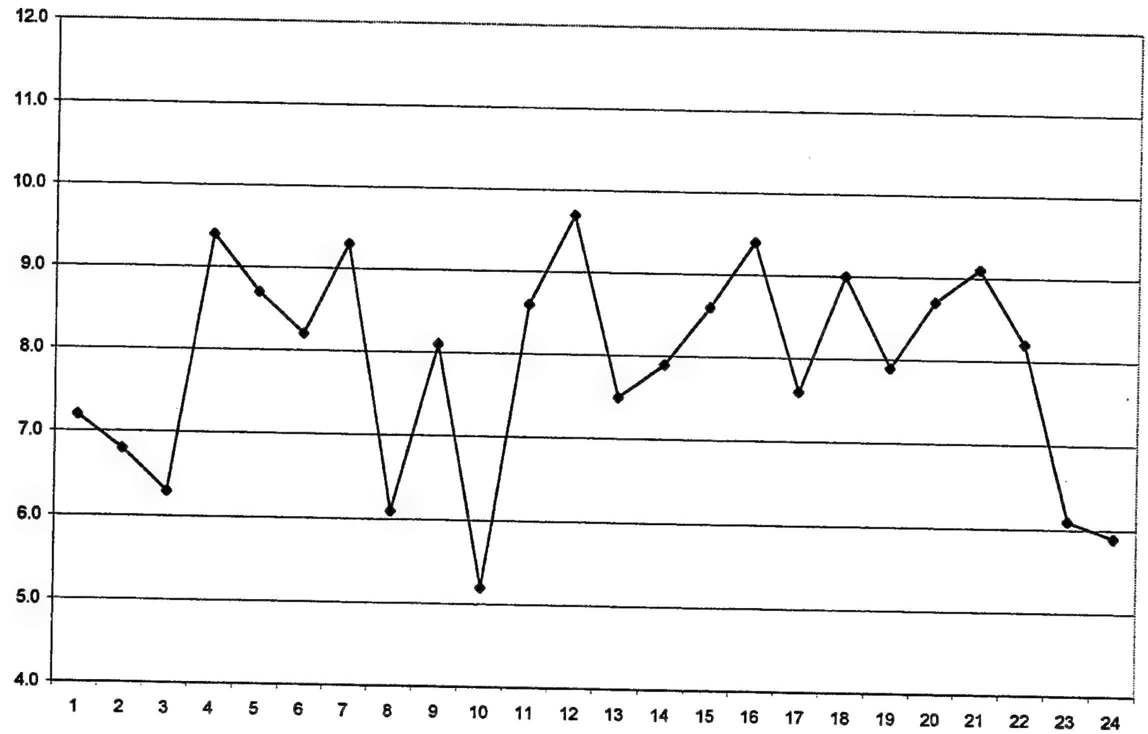


Pre Reorg PHUT Rate



Post Reorg PHUT Rate

Pre Reorg PSUT Rate



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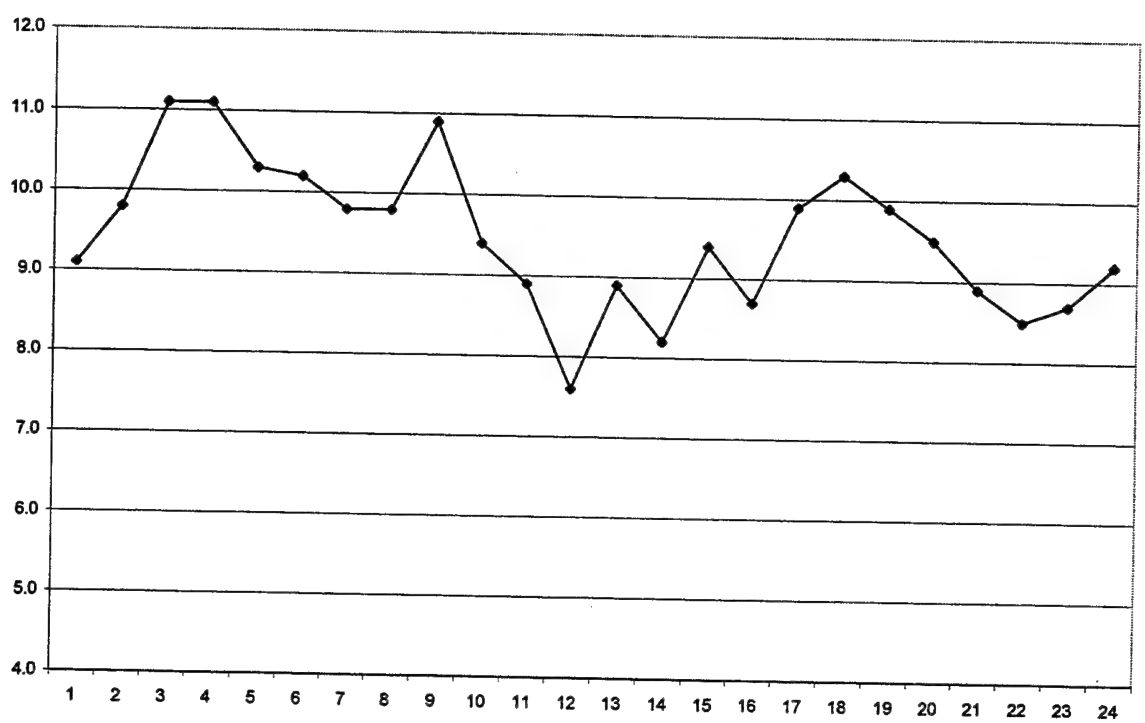
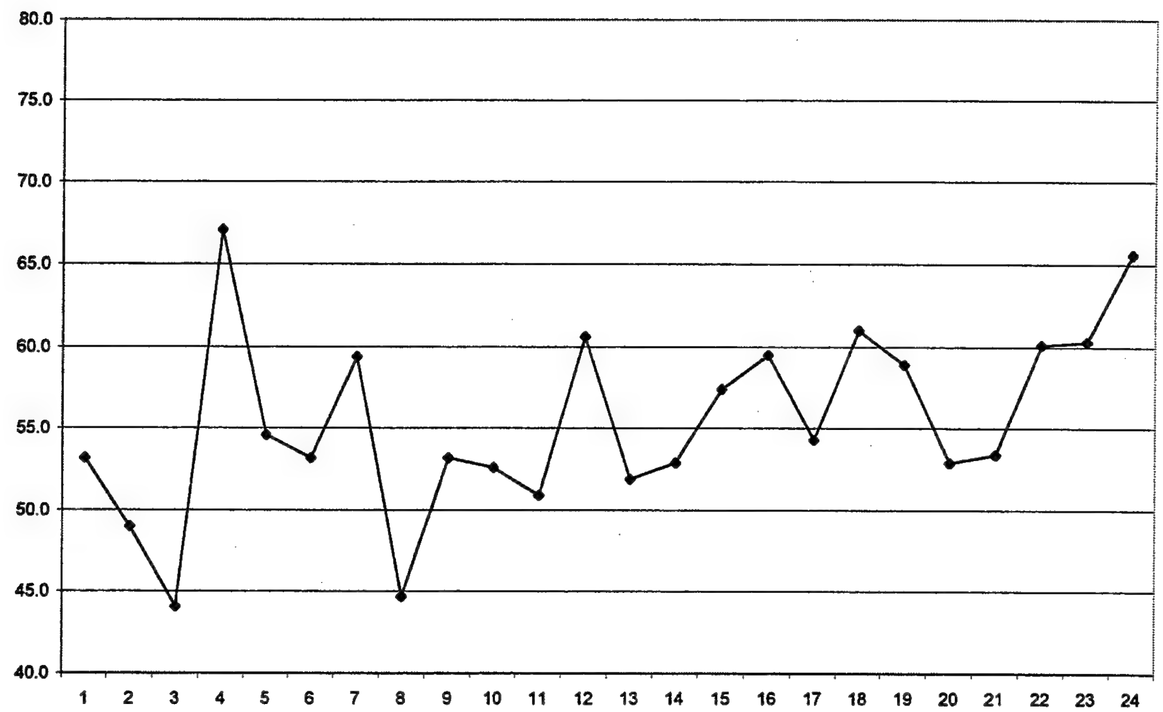


Pre Reorg AHUT Rate



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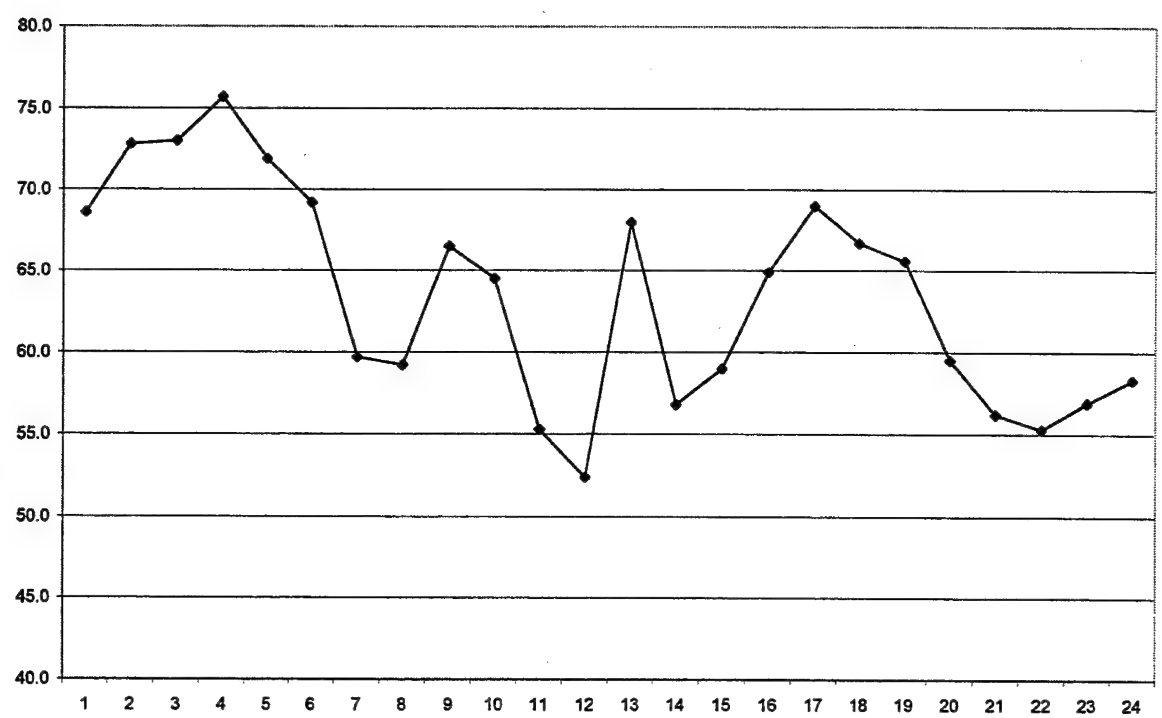
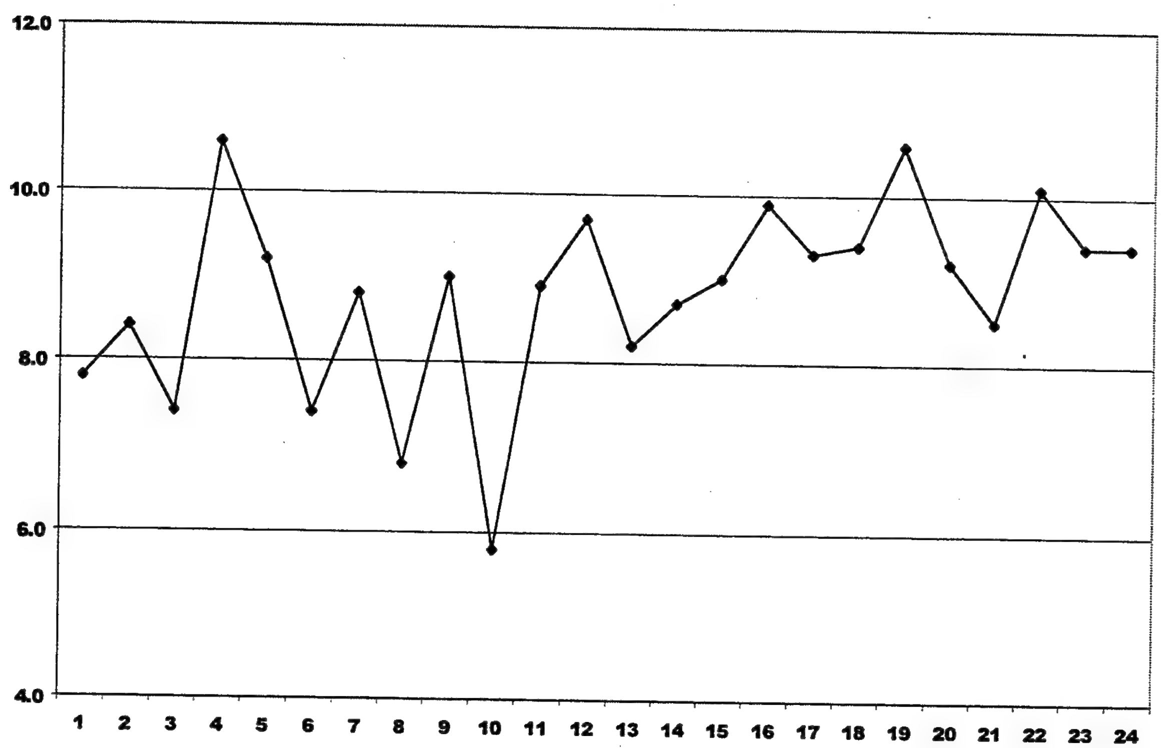
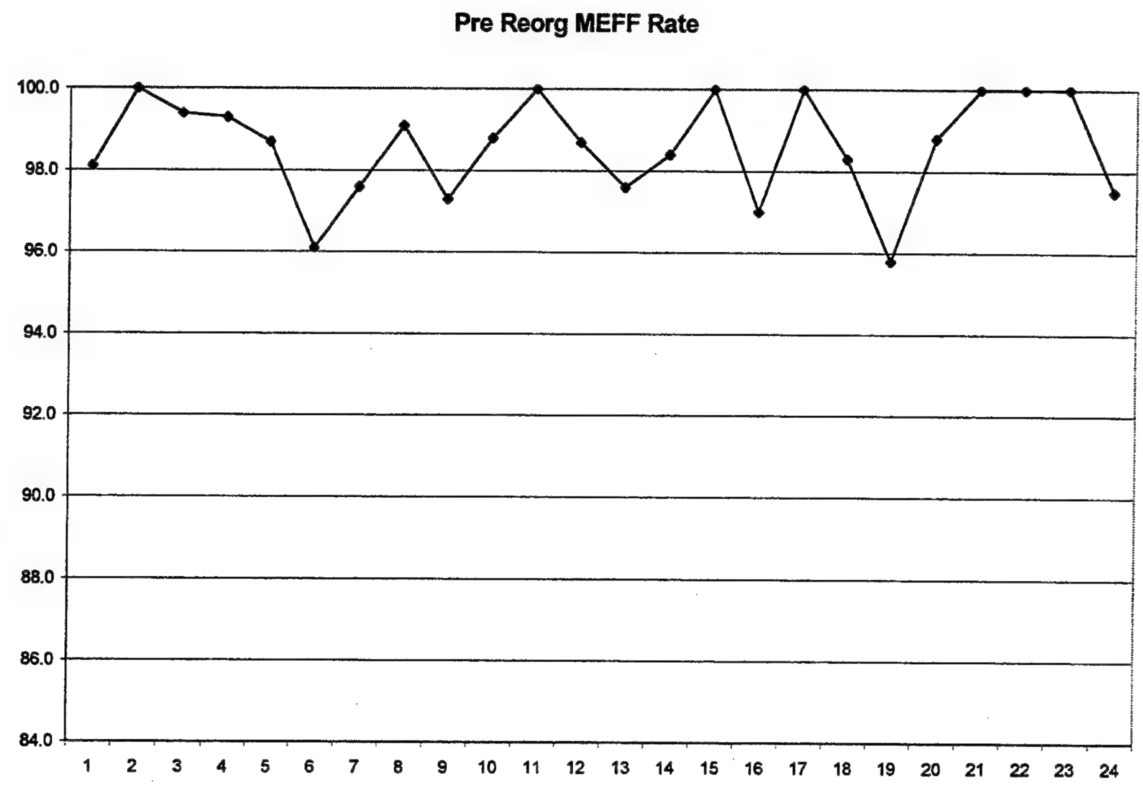
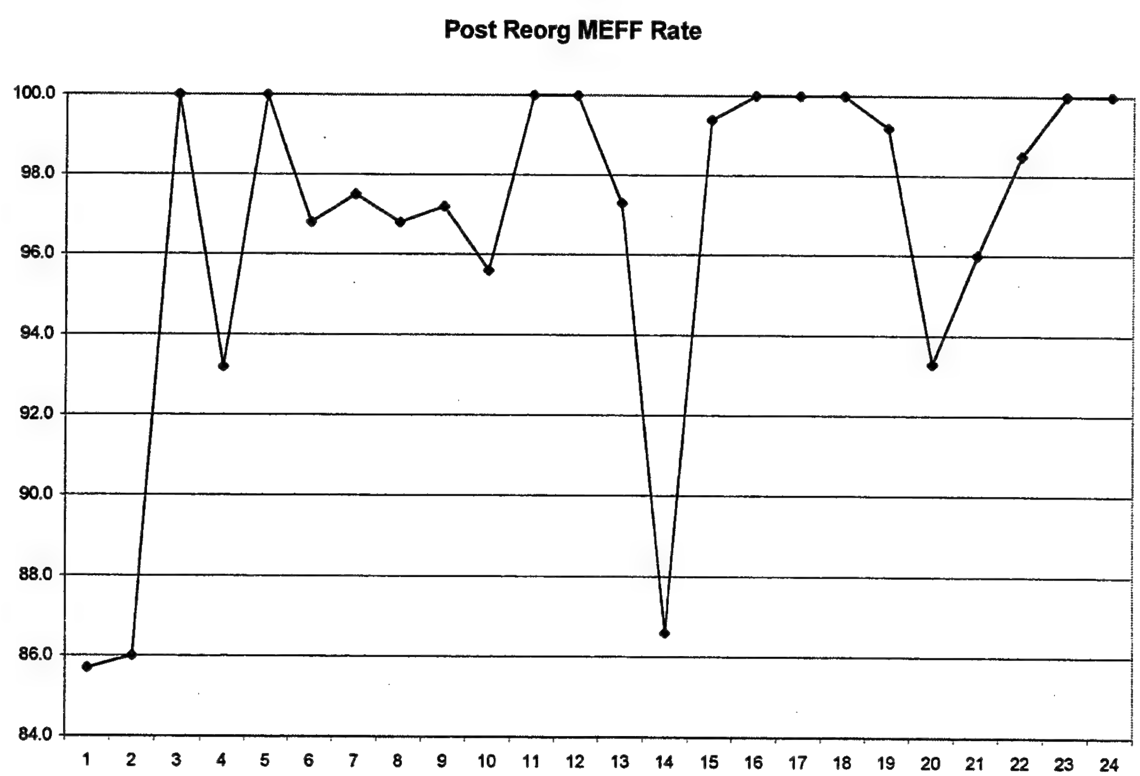


Pre Reorg ASUT Rate



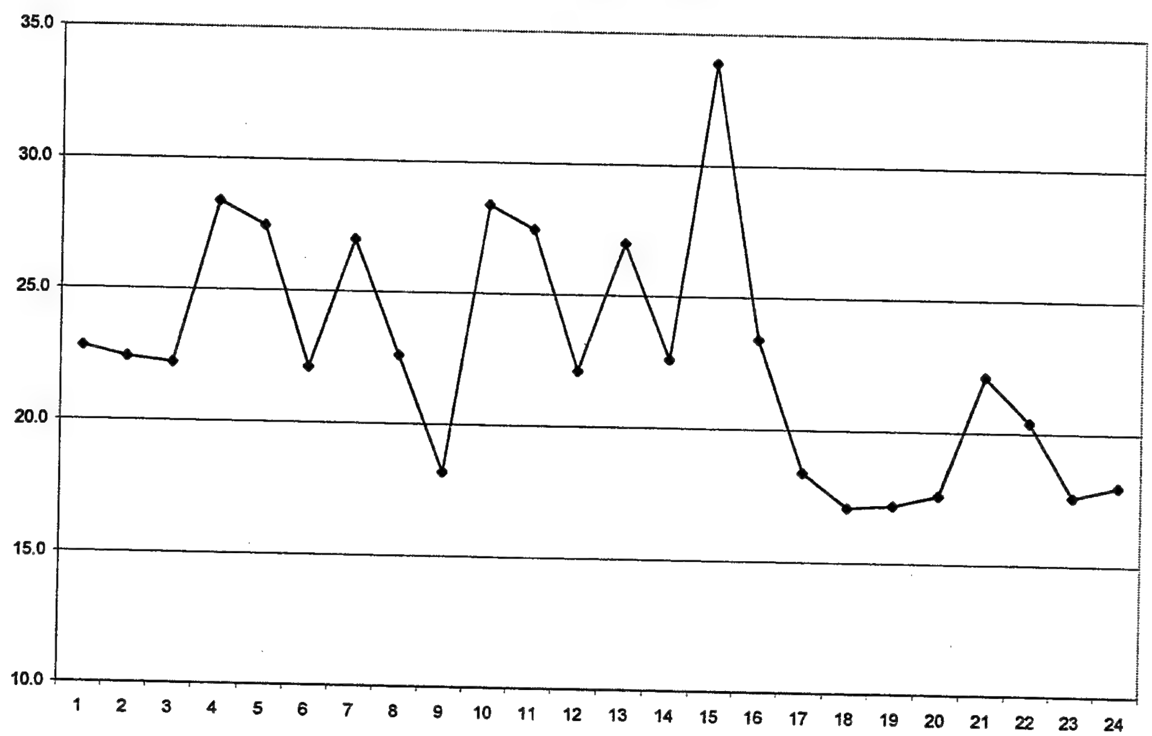
Post Reorg ASUT Rate


Pre Reorg MEFF Rate
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

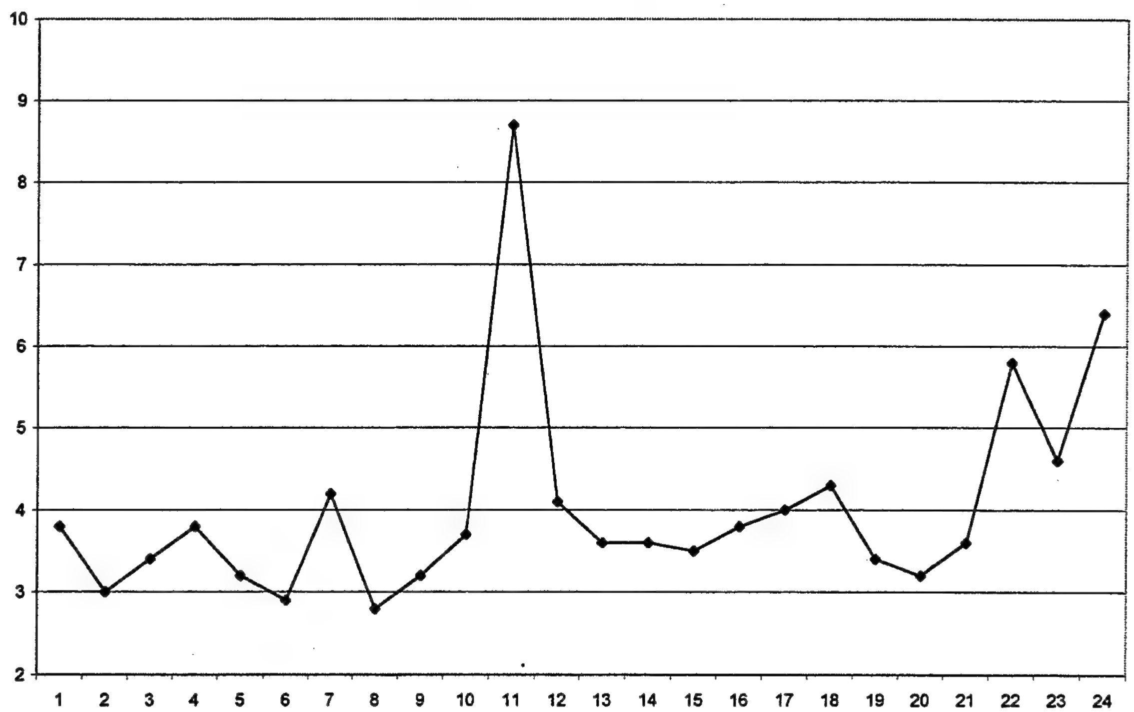

Post Reorg MEFF Rate
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Pre Reorg MFH Rate

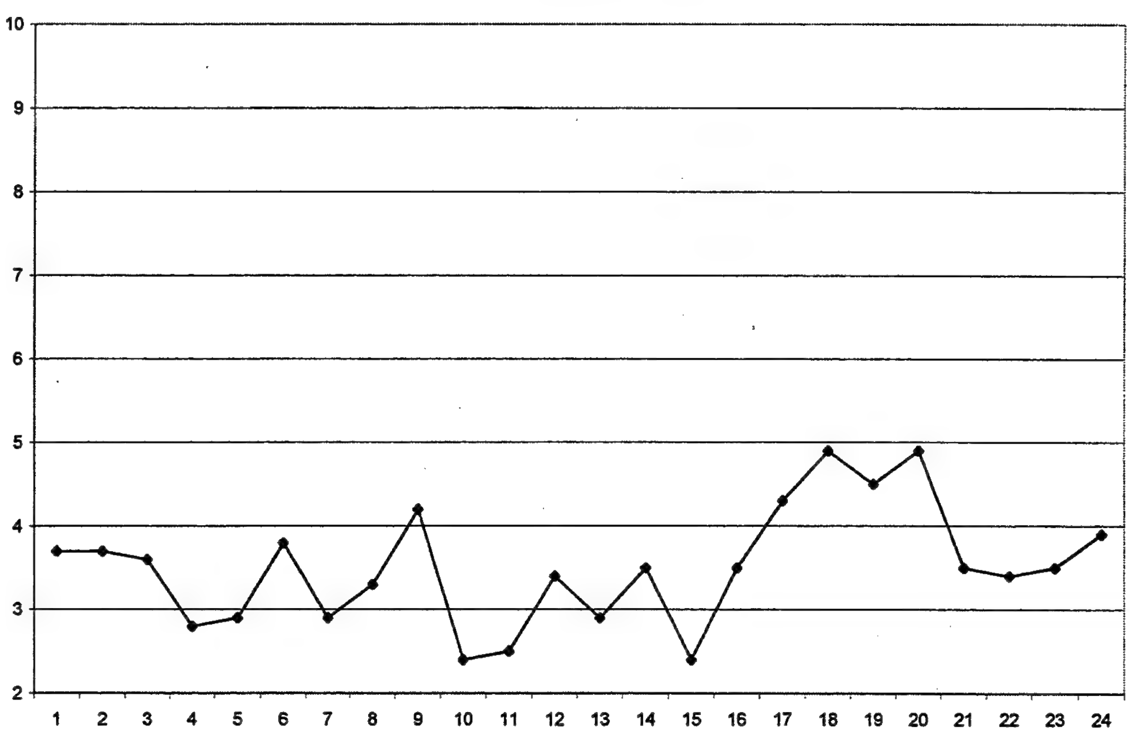
Post Reorg MFH Rate



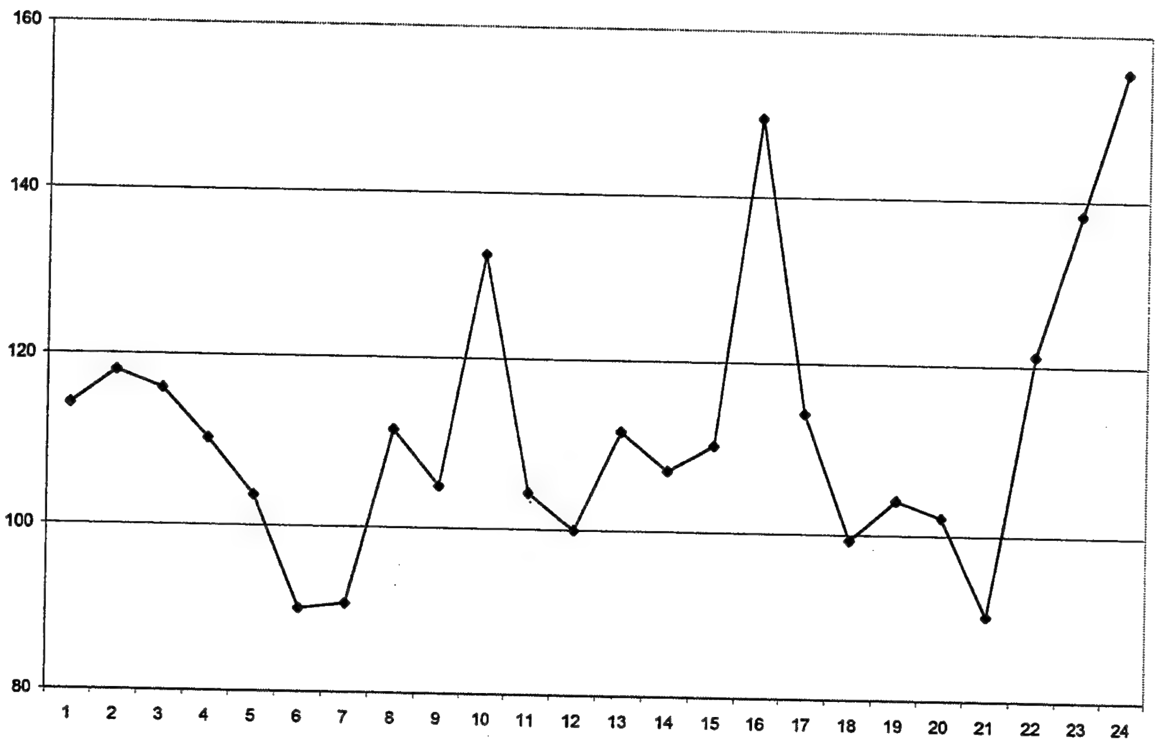
Pre Reorg MC/MFH Rate



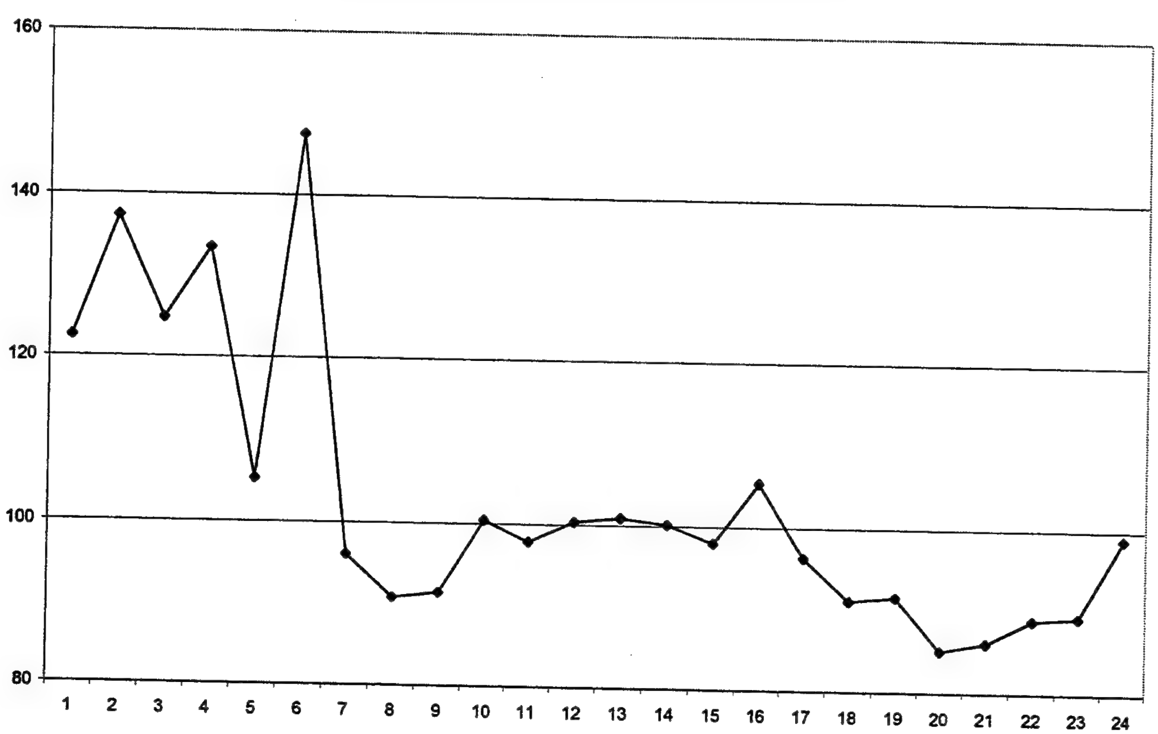
Post Reorg MC/MFH Rate

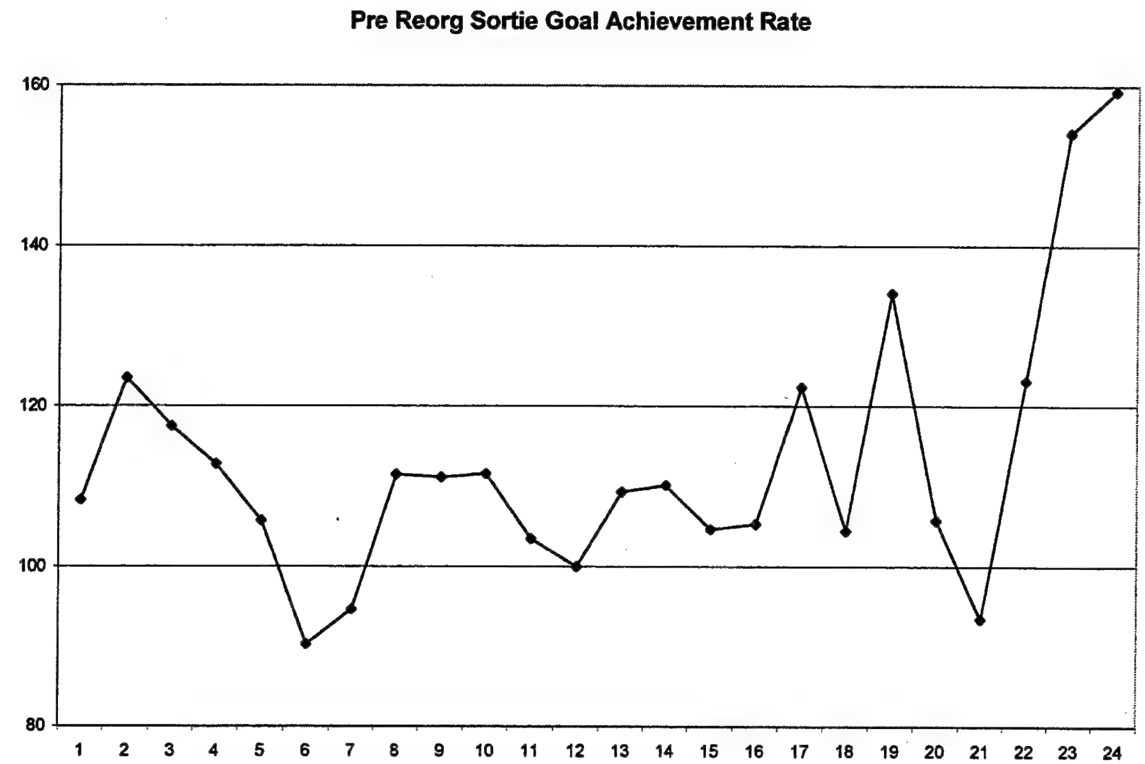


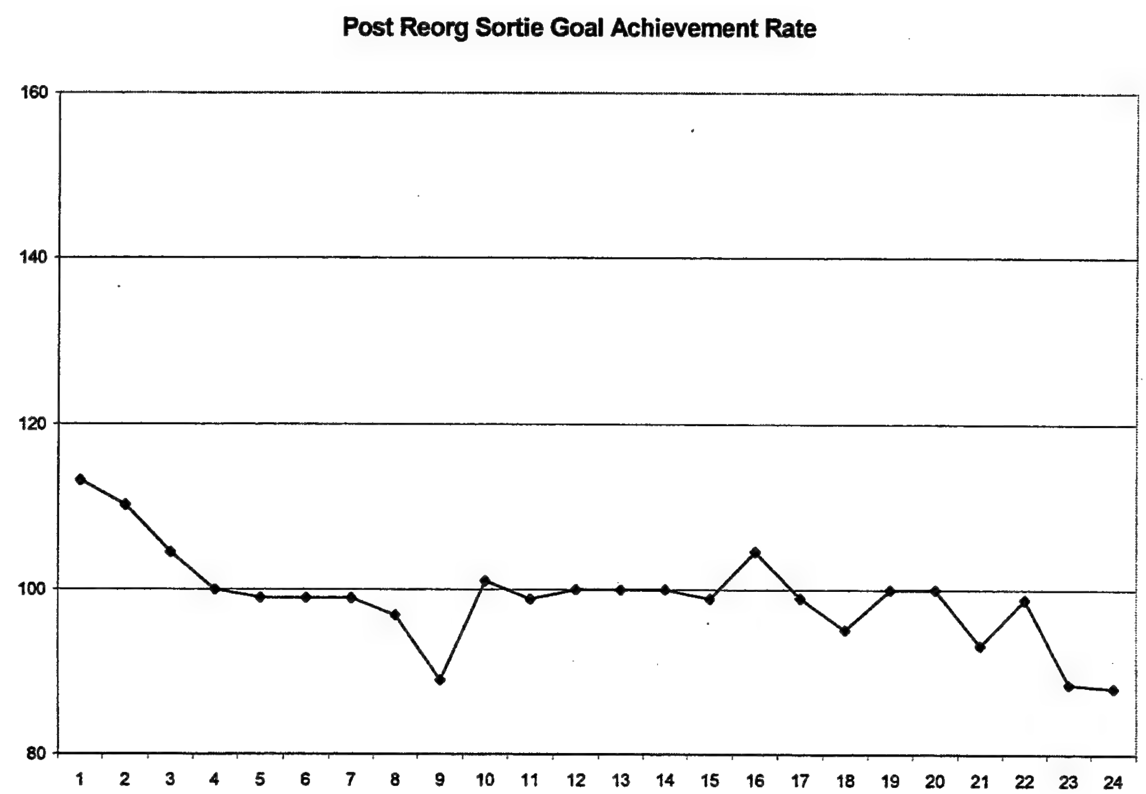
Pre Reorg Hourly Goal Achievement Rate



Post Reorg Hourly Goal Achievement Rate

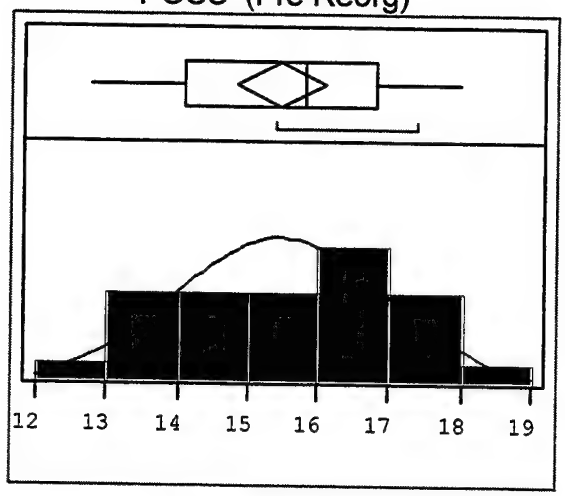



Pre Reorg Sortie Goal Achievement Rate
160
140
120
100
80
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24


Post Reorg Sortie Goal Achievement Rate
160
140
120
100
80
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

APPENDIX D: Normality Data

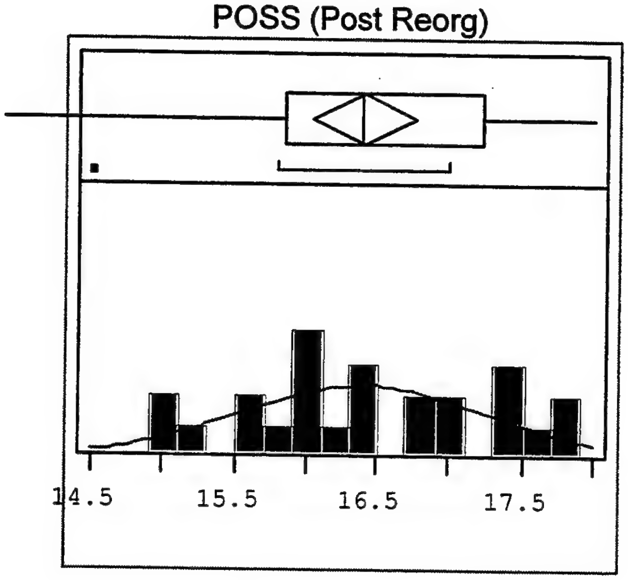
POSS (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.949460	0.2707

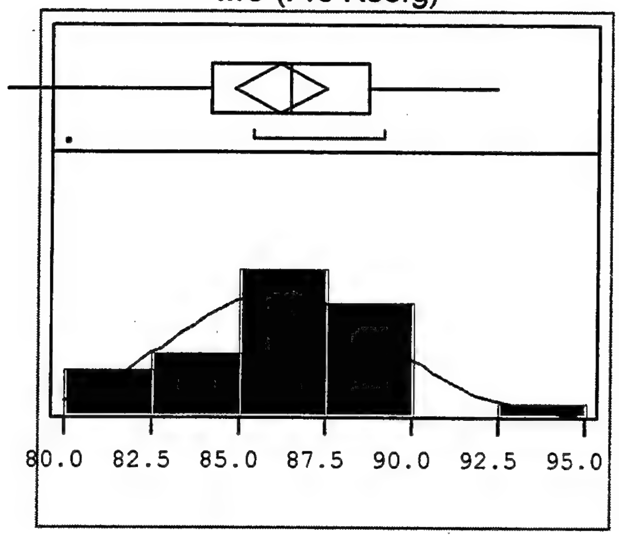
POSS (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.961373	0.4727

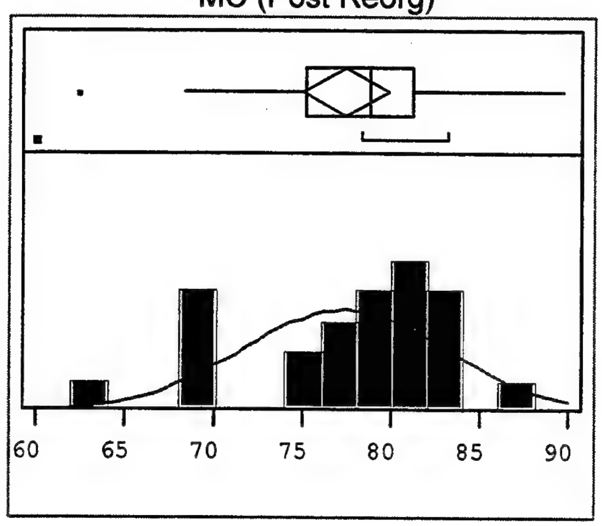
MC (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.966302	0.5801

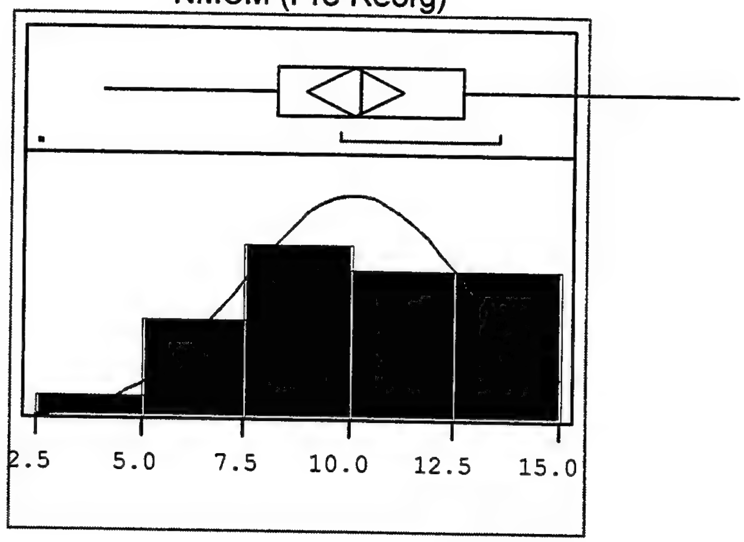
MC (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.917875	0.0525

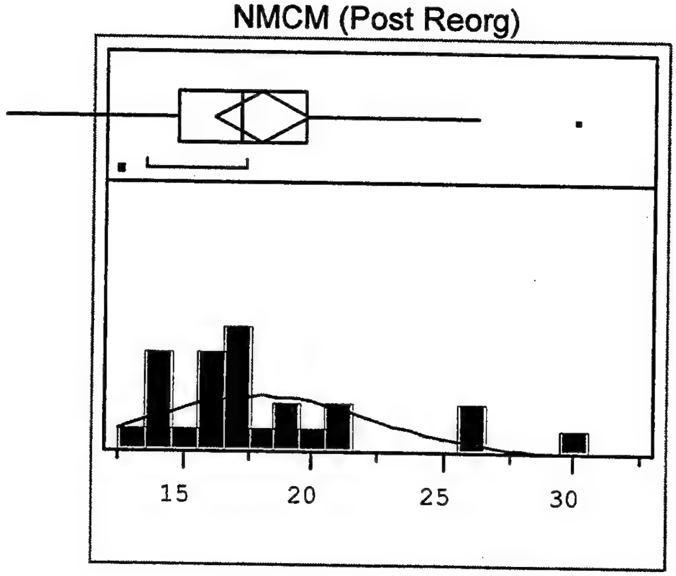
NMCM (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.968835	0.6390

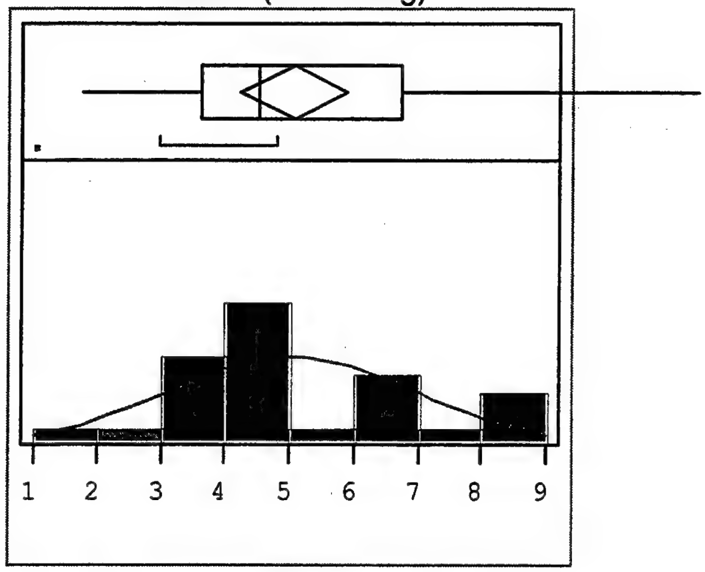
NMCM (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.875808	0.0060

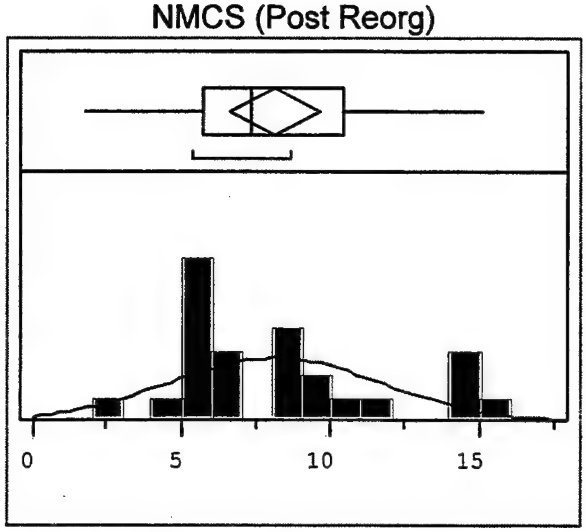
NMCS (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.937445	0.1470

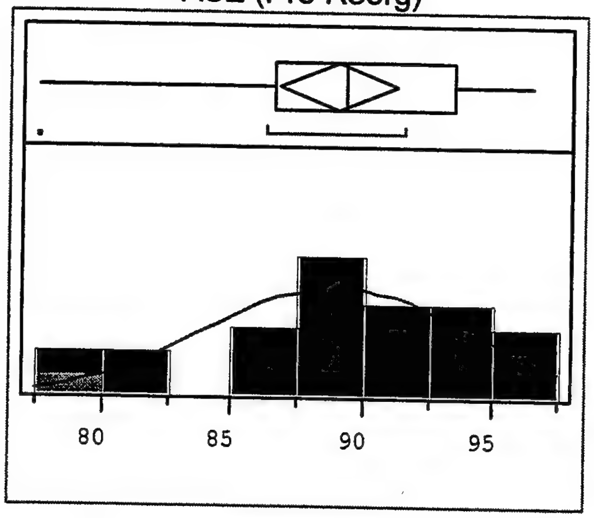
NMCS (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.914543	0.0441

ASE (Pre Reorg)

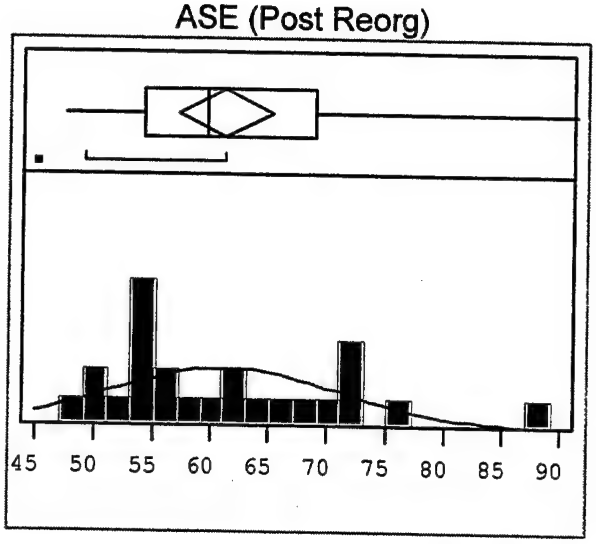


Test for Normality
Shapiro-Wilk W Test

W
0.935135

Prob<W
0.1303

ASE (Post Reorg)

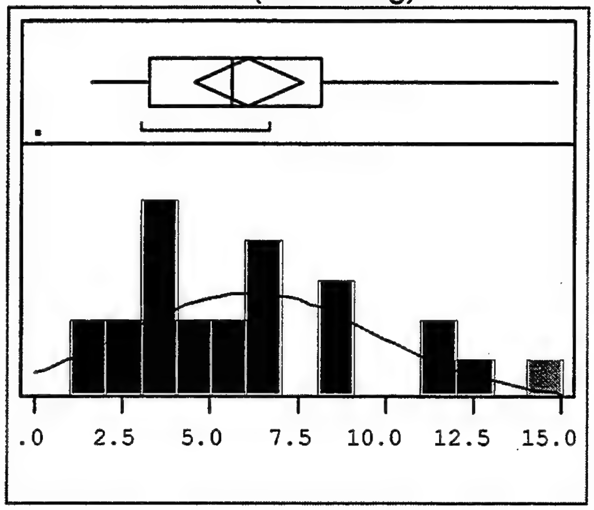


Test for Normality
Shapiro-Wilk W Test

W
0.938886

Prob<W
0.1584

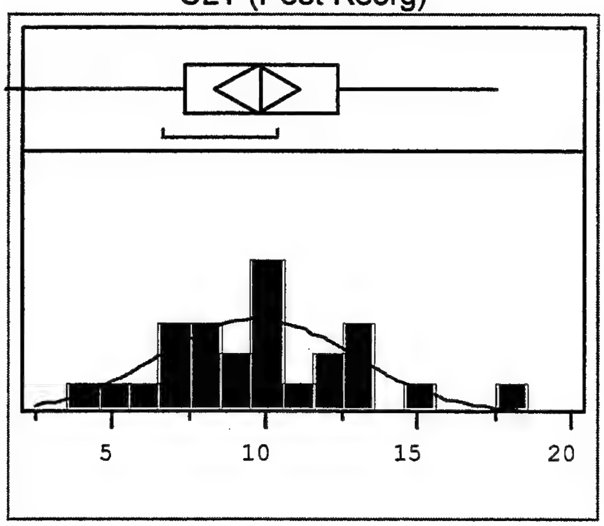
CLT (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.923010	0.0689

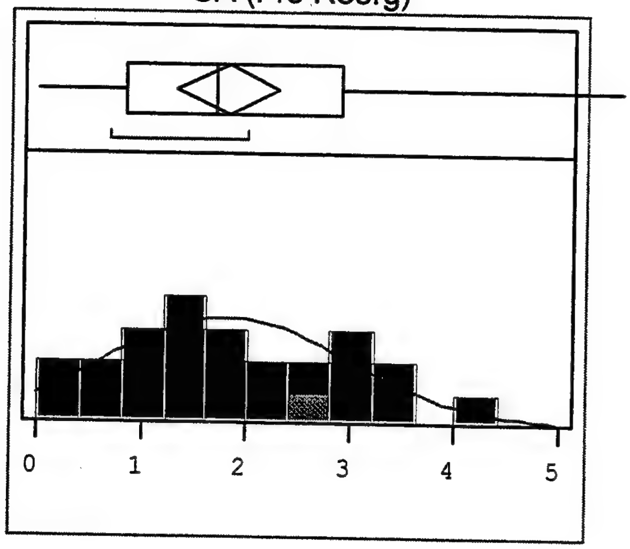
CLT (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.978737	0.8629

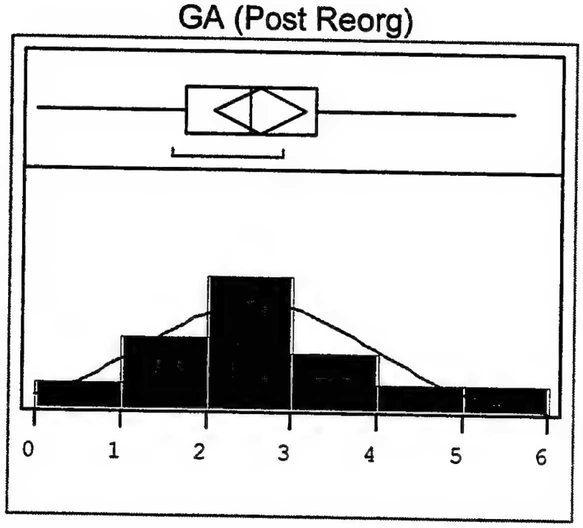
GA (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.961846	0.4825

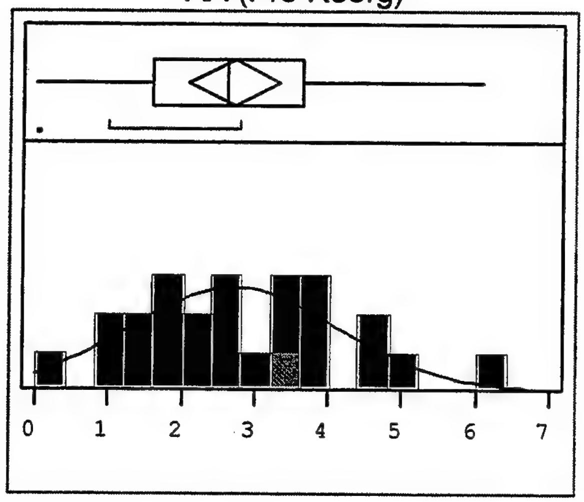
GA (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.979703	0.8813

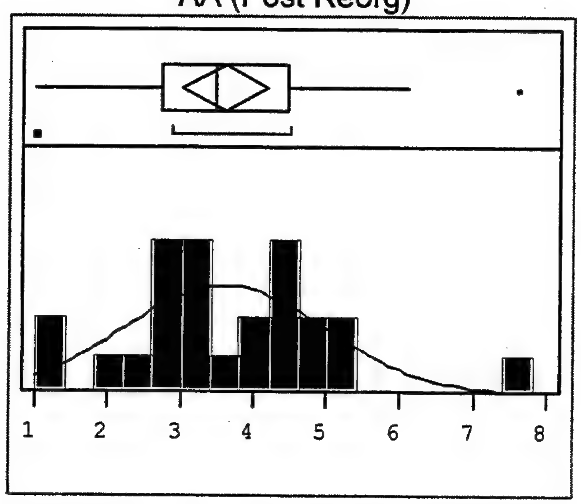
AA (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.981539	0.9131

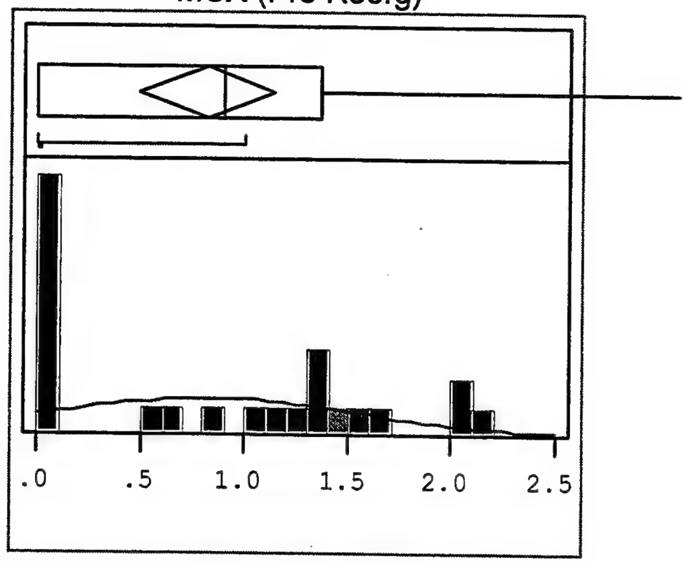
AA (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.940039	0.1681

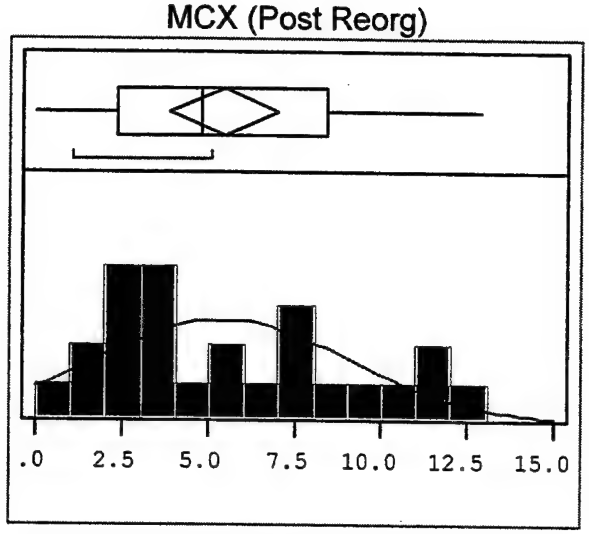
MCX (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.862855	0.0031

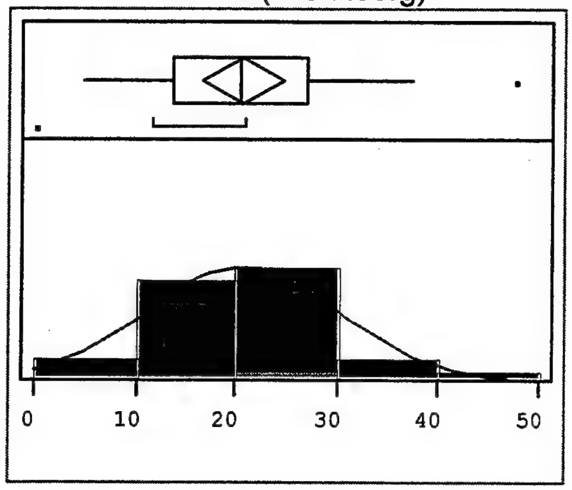
MCX (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.939894	0.1668

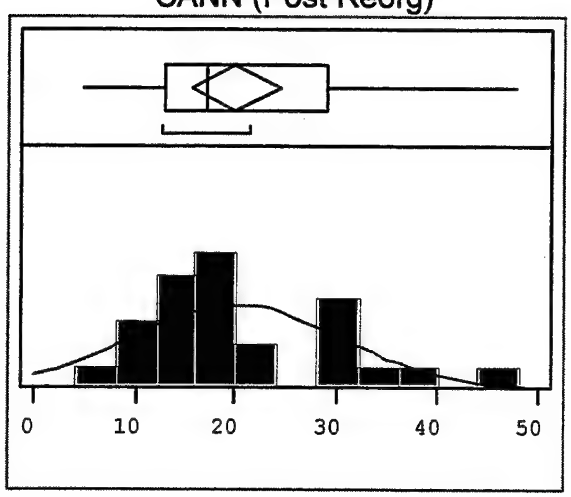
CANN (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.953118	0.3235

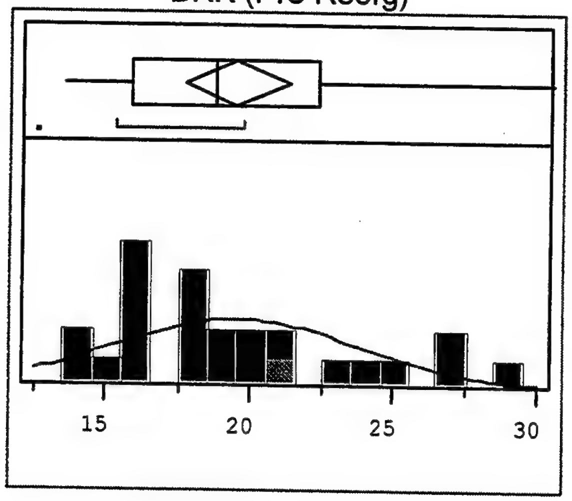
CANN (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.929143	0.0952

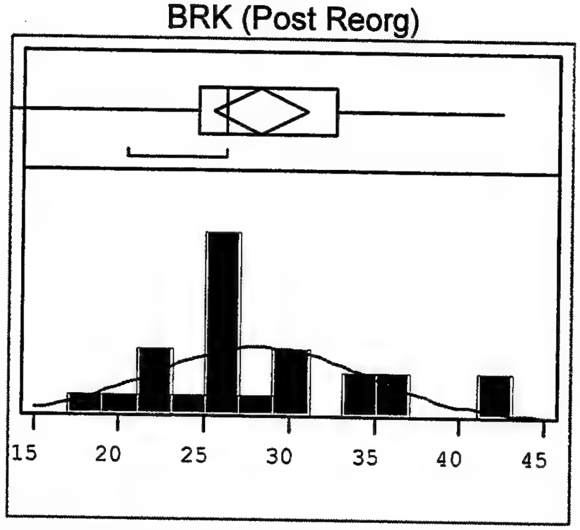
BRK (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.934430	0.1256

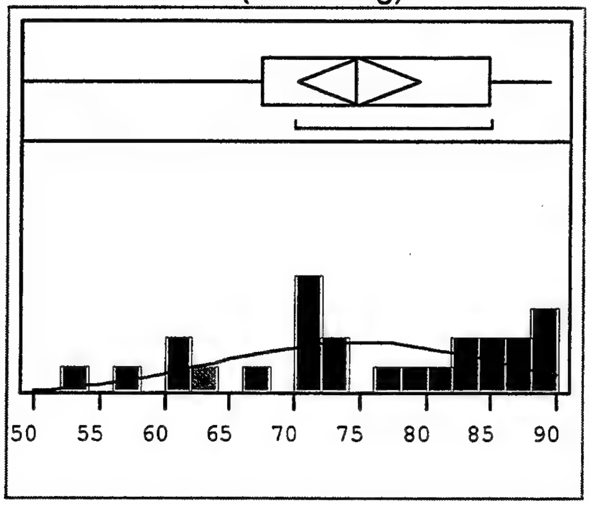
BRK (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.947148	0.2413

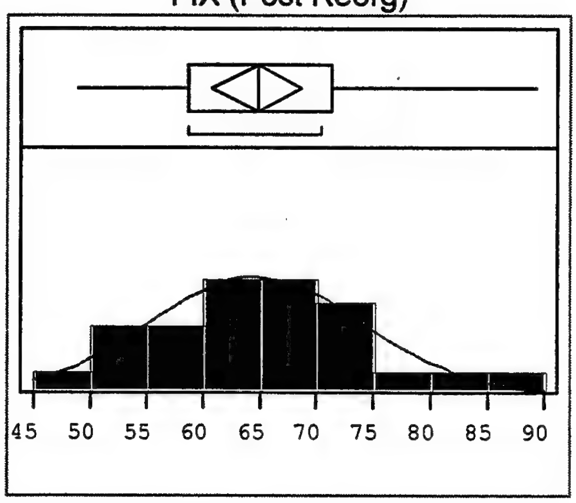
FIX (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.936910	0.1430

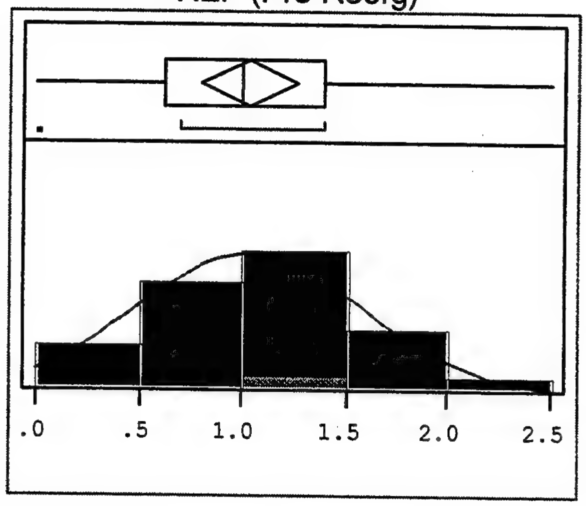
FIX (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.981503	0.9125

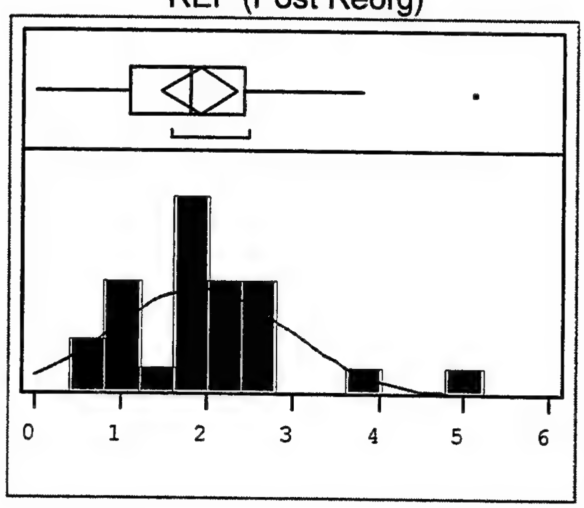
REP (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.984206	0.9506

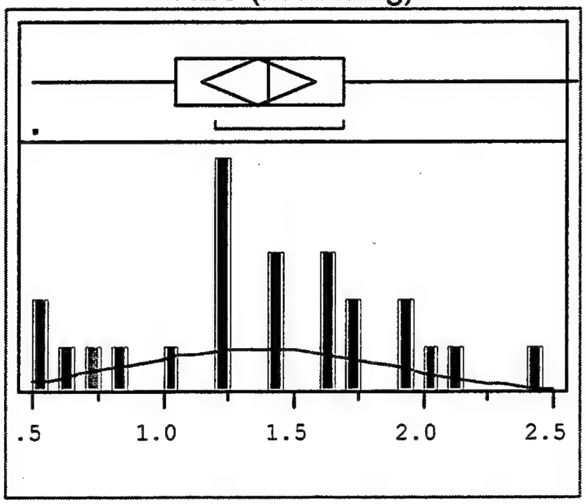
REP (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.902744	0.0237

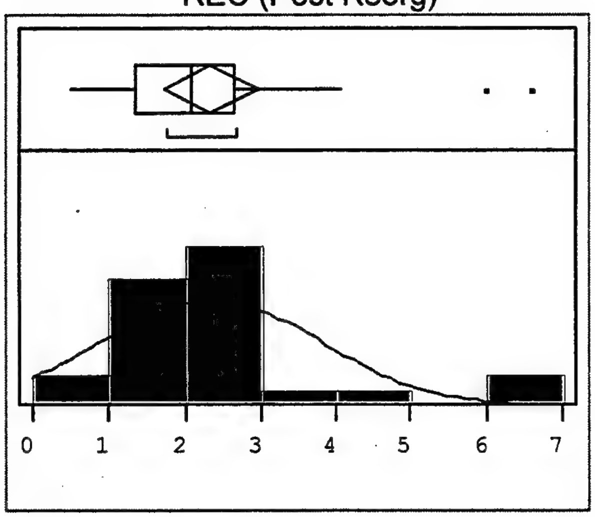
REC (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.968851	0.6394

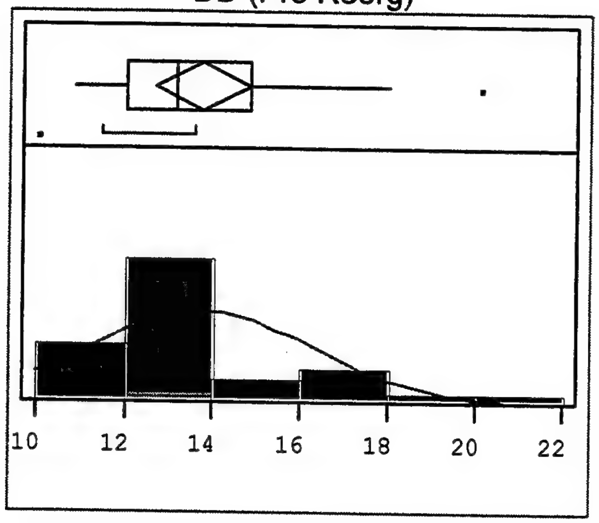
REC (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.825747	0.0005

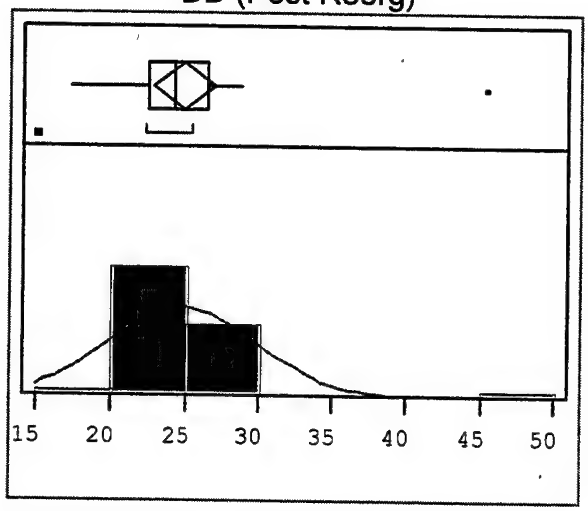
DD (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.866080	0.0037

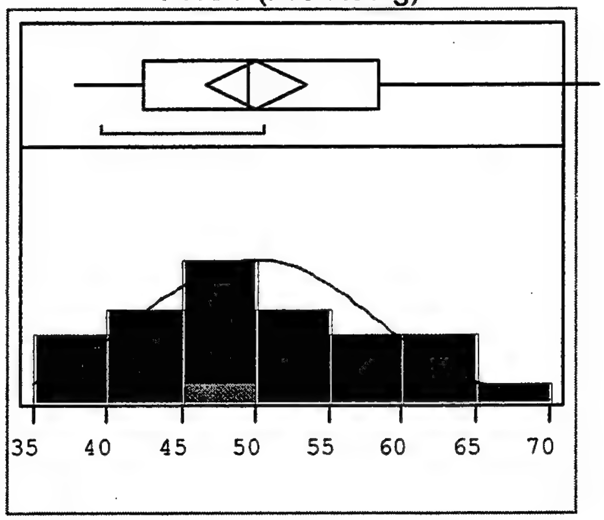
DD (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.702624	<.0001

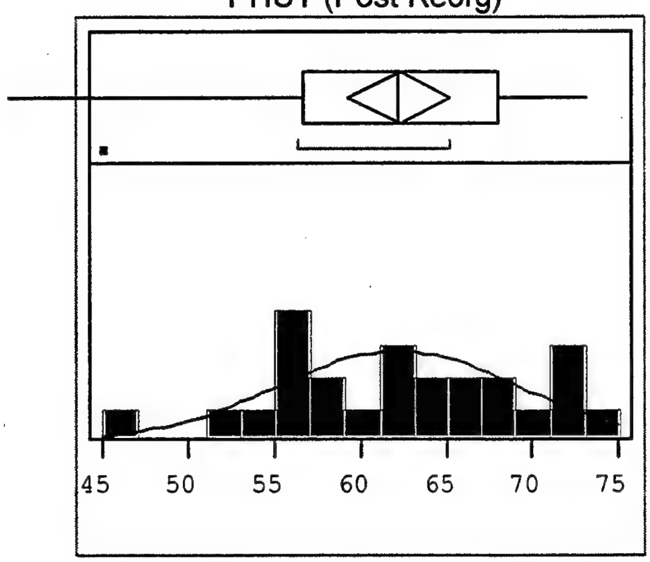
PHUT (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.950681	0.2875

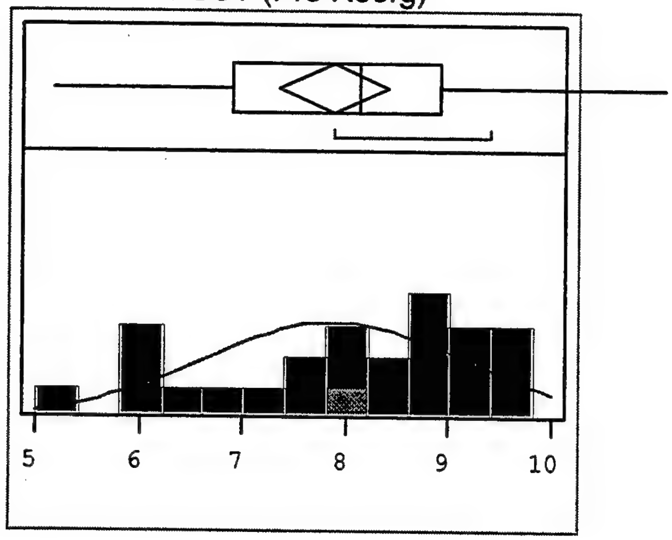
PHUT (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.971807	0.7093

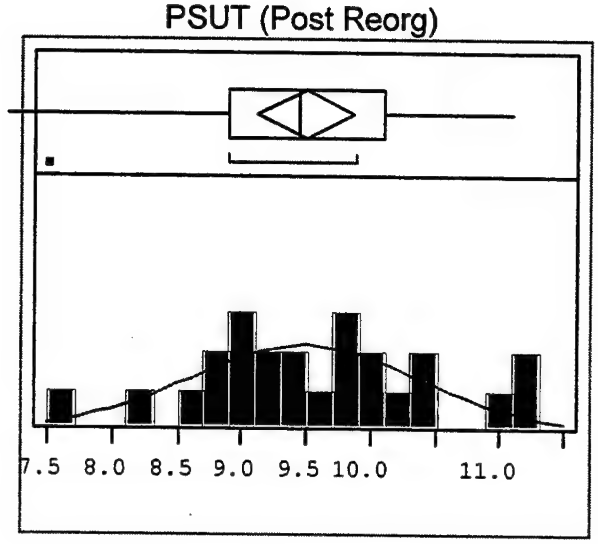
PSUT (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.939768	0.1658

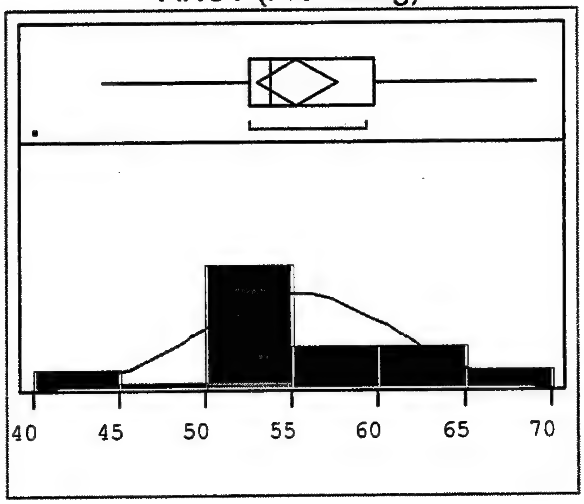
PSUT (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.977271	0.8331

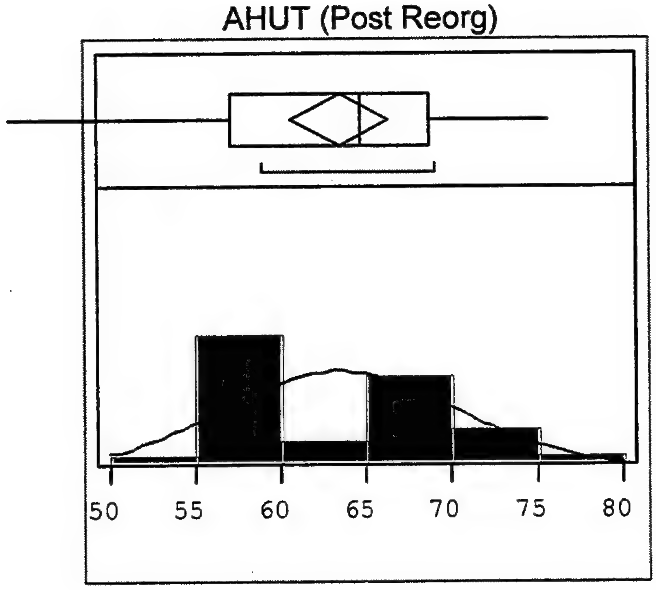
AHUT (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.956225	0.3747

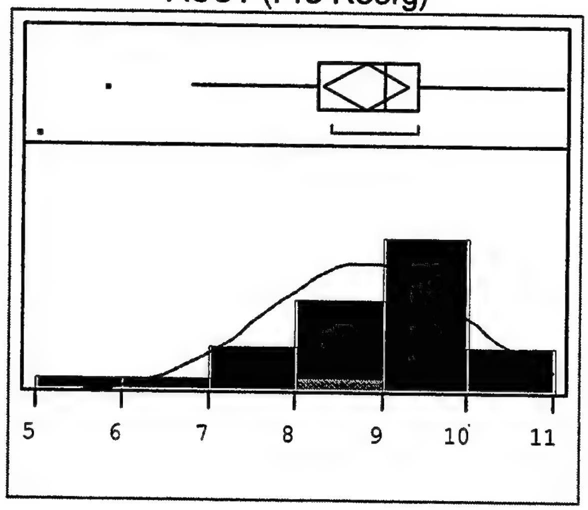
AHUT (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.946563	0.2344

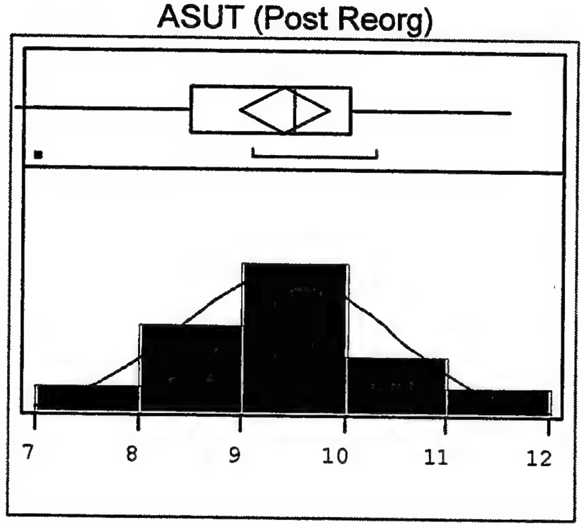
ASUT (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.948694	0.2606

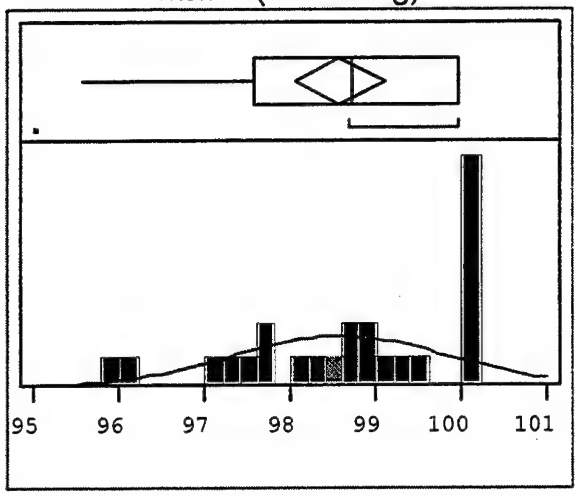
ASUT (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.976299	0.8123

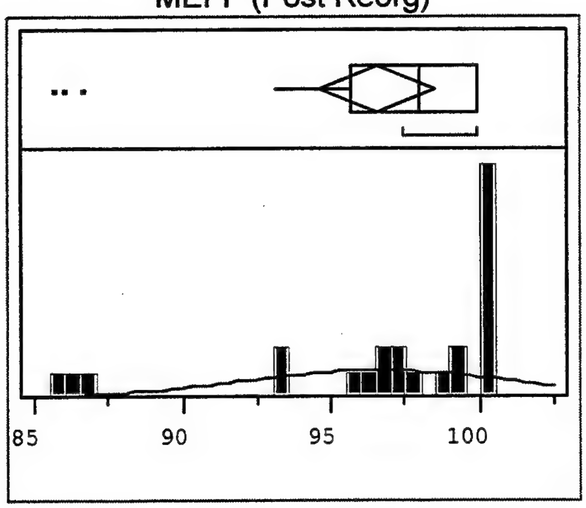
MEFF (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.906722	0.0292

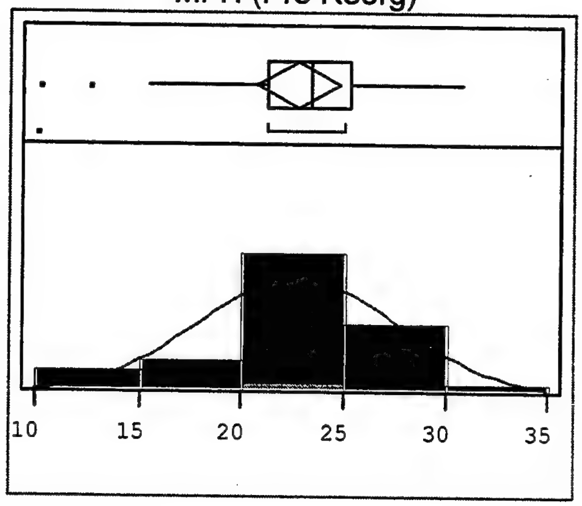
MEFF (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.735732	<.0001

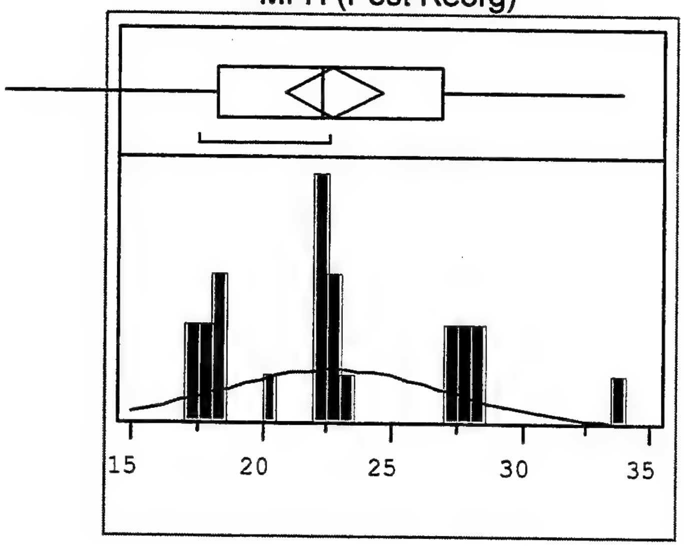
MFH (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.927663	0.0881

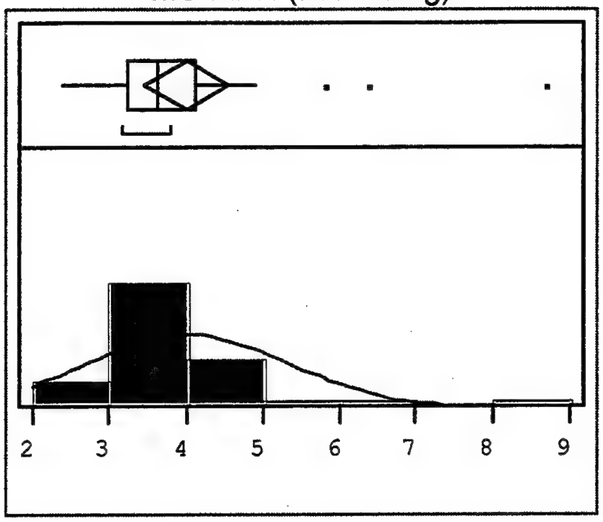
MFH (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.916029	0.0477

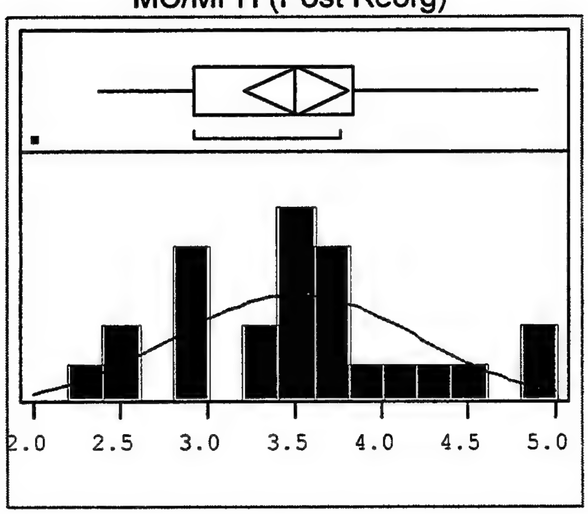
MC/MFH (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.718755	<.0001

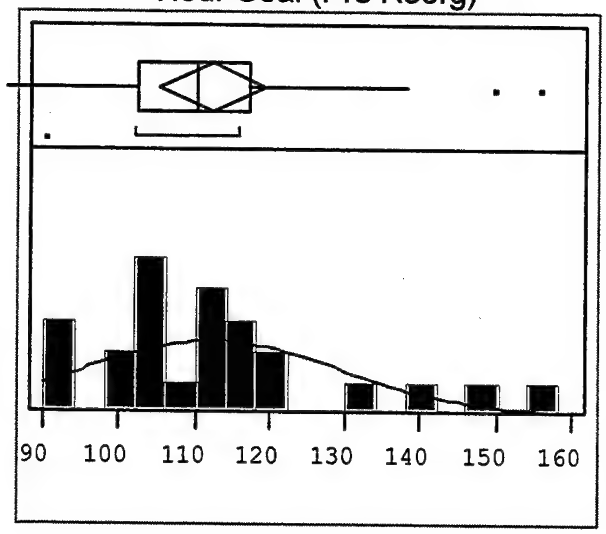
MC/MFH (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.955796	0.3673

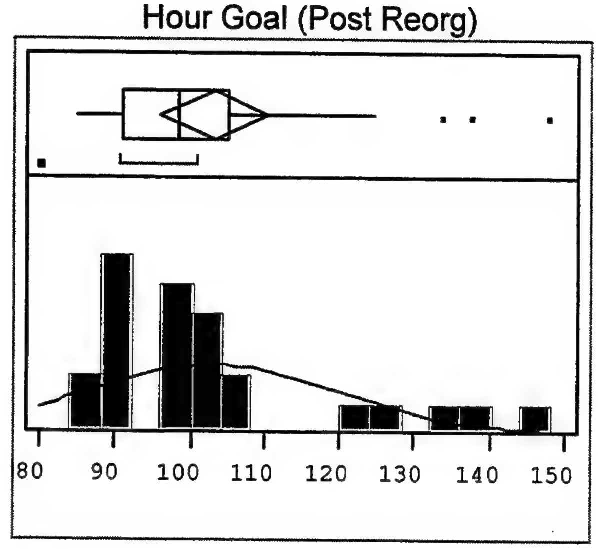
Hour Goal (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.894695	0.0156

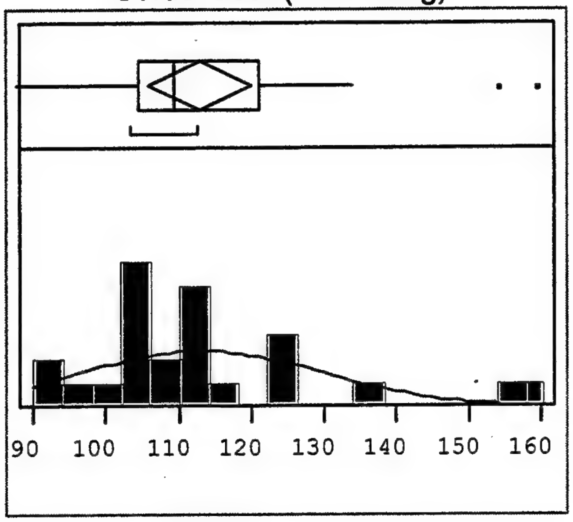
Hour Goal (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.821011	0.0004

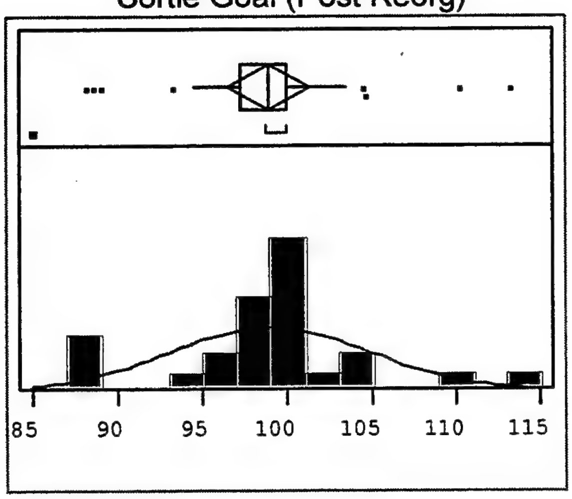
Sortie Goal (Pre Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.857690	0.0024

Sortie Goal (Post Reorg)



Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.890870	0.0128

APPENDIX E: Homogeneity of Variances of Key Variables

MC Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.5882	1	46	0.0375
Brown-Forsythe	3.9270	1	46	0.0535
Levene	5.7253	1	46	0.0209
Bartlett	7.8390	1	?	0.0051

NMCS Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.8350	1	46	0.0120
Brown-Forsythe	6.0266	1	46	0.0179
Levene	6.4869	1	46	0.0143
Bartlett	7.6254	1	?	0.0058

AHUT Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9192	1	46	0.3427
Brown-Forsythe	1.6527	1	46	0.2050
Levene	1.9425	1	46	0.1701
Bartlett	0.5513	1	?	0.4578

ASUT Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.2380	1	46	0.6280
Brown-Forsythe	0.0399	1	46	0.8426
Levene	0.0641	1	46	0.8012
Bartlett	0.2583	1	?	0.6113

MC/MFH Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.4663	1	46	0.2321
Brown-Forsythe	0.7871	1	46	0.3796
Levene	1.9199	1	46	0.1725
Bartlett	8.2163	1	?	0.0042

CLT Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.3855	1	46	0.5377
Brown-Forsythe	0.3616	1	46	0.5505
Levene	0.4188	1	46	0.5208
Bartlett	0.3906	1	?	0.5320

MCX Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	20.2230	1	46	<.0001
Brown-Forsythe	32.5785	1	46	<.0001
Levene	43.7179	1	46	<.0001
Bartlett	42.2952	1	?	<.0001

Hour Goal Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0005	1	46	0.9825
Brown-Forsythe	0.0160	1	46	0.9000
Levene	0.0240	1	46	0.8775
Bartlett	0.0007	1	?	0.9796

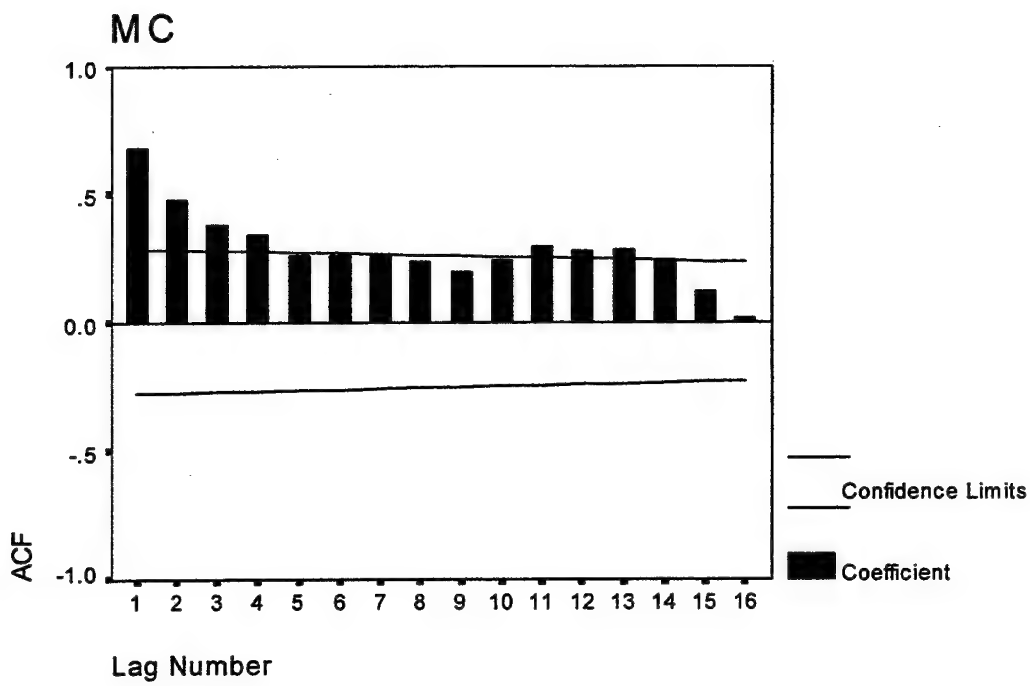
Sortie Goal Results:

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.5522	1	46	0.0382
Brown-Forsythe	7.1012	1	46	0.0106
Levene	10.2699	1	46	0.0025
Bartlett	21.4953	1	?	<.0001

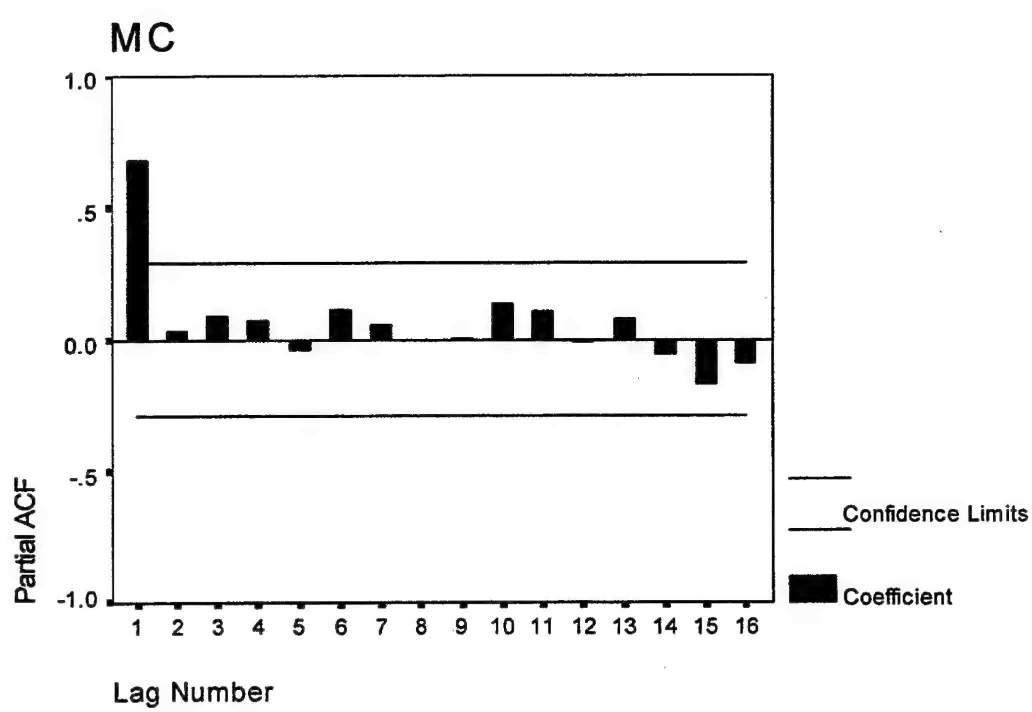
APPENDIX F: Runs Test Results

```
Autocorrelations:   MC

     Auto-  Stand.
Lag  Corr.    Err. -1   -.75   -.5 -.25    0    .25   .5    .75    1   Box-Ljung  Prob.
                    +----+----+----+----+----+----+----+----+
  1   .675    .140                    .    I*****.*******               23.250   .000
  2   .472    .138                    .    I*****.***                   34.884   .000
  3   .378    .137                     .   I****.***                    42.511   .000
  4   .334    .135                     .   I****.**                     48.579   .000
  5   .255    .134                     .   I*****                       52.221   .000
  6   .254    .132                     .   I*****                       55.921   .000
  7   .260    .131                     .   I*****                       59.888   .000
  8   .232    .129                     .   I*****                       63.130   .000
  9   .194    .127                     .   I****.                       65.440   .000
 10   .240    .126                     .   I*****                       69.074   .000
 11   .293    .124                     .   I****.*                      74.625   .000
 12   .273    .122                     .   I*****                       79.598   .000
 13   .278    .121                     .   I****.*                      84.892   .000
 14   .240    .119                     .   I*****                       88.943   .000
 15   .115    .117                     .   I**   .                      89.910   .000
 16   .013    .115                     .   *     .                      89.923   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  48      Computable first lags:  47
```

```
Partial Autocorrelations:   MC

   Pr-Aut- Stand.
Lag  Corr.    Err. -1   -.75   -.5 -.25    0    .25   .5    .75    1
                    +----+----+----+----+----+----+----+----+
  1   .675    .144                    .    I*****.*******
  2   .031    .144                    .    I*     .
  3   .089    .144                    .    I**    .
  4   .074    .144                    .    I*     .
  5  -.036    .144                    .   *I      .
  6   .112    .144                    .    I**    .
  7   .055    .144                    .    I*     .
  8  -.003    .144                    .    *      .
  9   .001    .144                    .    *      .
 10   .133    .144                    .    I***   .
 11   .106    .144                    .    I**    .
 12  -.009    .144                    .    *      .
 13   .076    .144                    .    I**    .
 14  -.057    .144                    .   *I      .
 15  -.171    .144                    . ***I      .
 16  -.091    .144                    .  **I      .

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  48      Computable first lags:  47
```



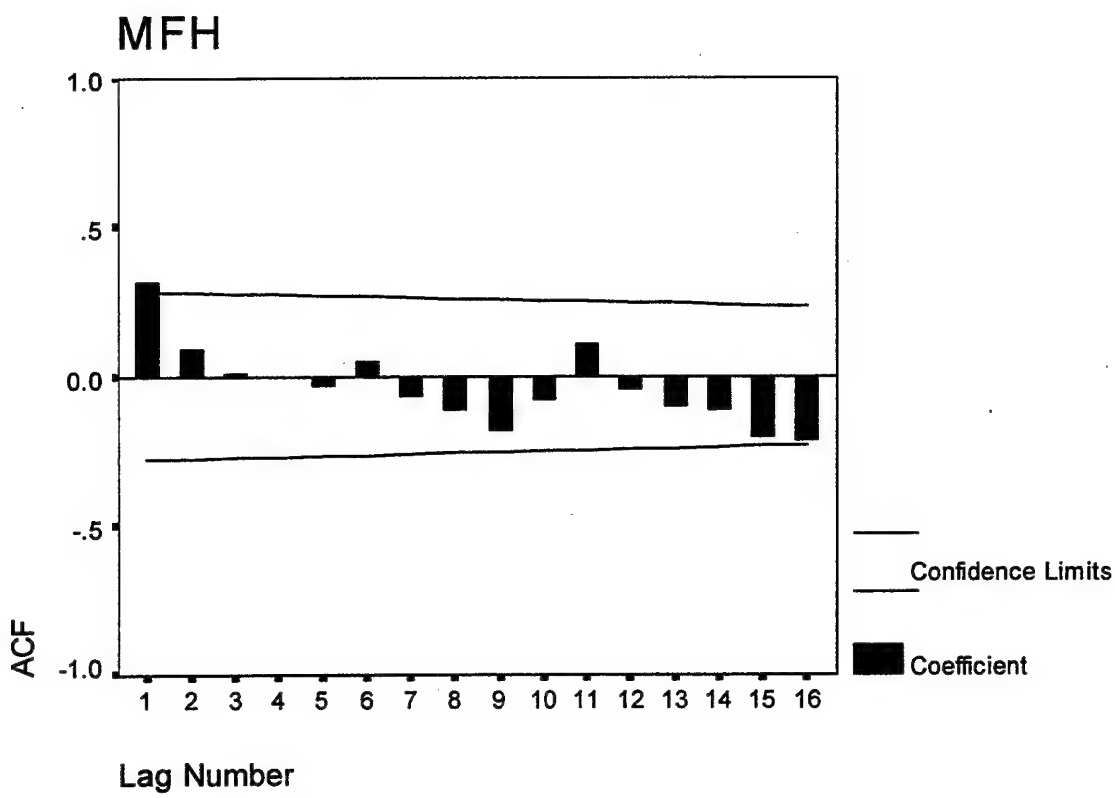
MC
1.0
.5
0.0
-.5
-1.0
ACF
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Lag Number
Confidence Limits
Coefficient

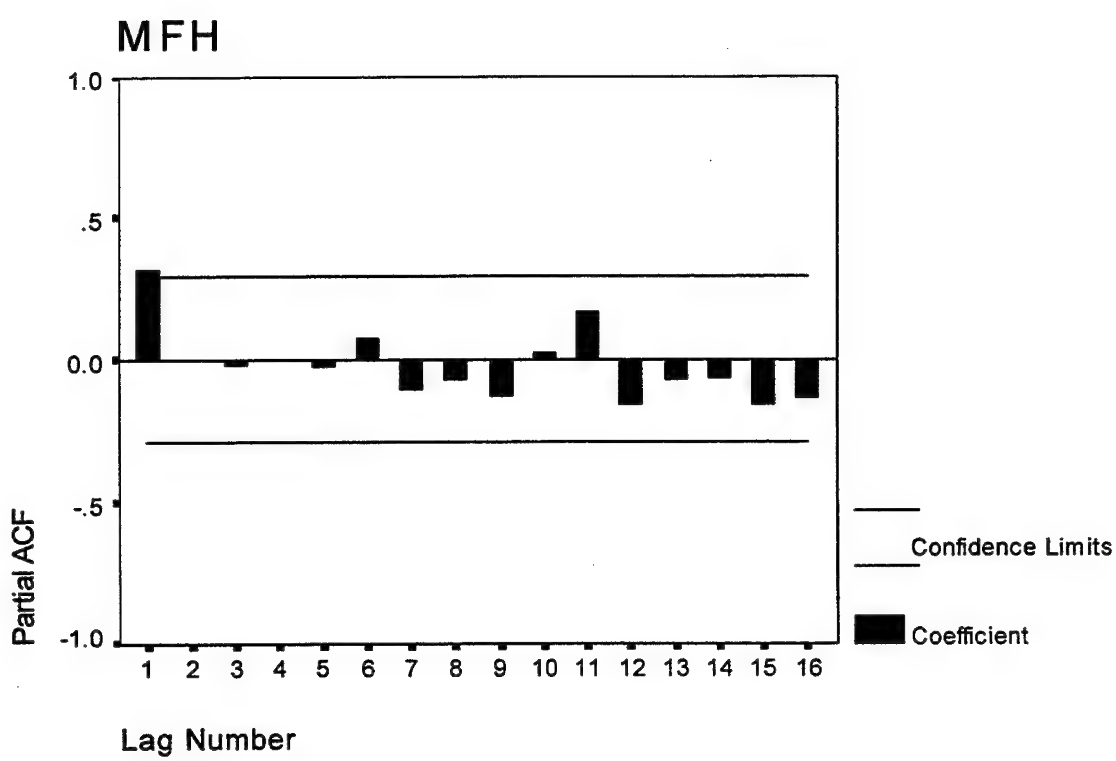


MC
1.0
.5
0.0
-.5
-1.0
Partial ACF
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Lag Number
Confidence Limits
Coefficient

```
Autocorrelations:    MFH

     Auto- Stand.
Lag  Corr.   Err. -1  -.75 -.5 -.25   0   .25  .5   .75   1  Box-Ljung   Prob.
                  +----+----+----+----+----+----+----+----+
  1   .311   .140               .     I******                    4.943   .026
  2   .092   .138               .     I**   .                    5.382   .068
  3   .010   .137                .    *    .                     5.388   .146
  4  -.005   .135                .    *    .                     5.389   .250
  5  -.030   .134                .   *I    .                     5.438   .365
  6   .049   .132                .    I*   .                     5.576   .472
  7  -.064   .131                .   *I    .                     5.815   .562
  8  -.111   .129                .  **I    .                     6.555   .585
  9  -.182   .127                .****I    .                     8.588   .476
 10  -.080   .126                .  **I    .                     8.997   .532
 11   .108   .124                .    I**  .                     9.760   .552
 12  -.044   .122                .   *I    .                     9.888   .626
 13  -.103   .121                .  **I    .                    10.620   .643
 14  -.114   .119                .  **I    .                    11.540   .643
 15  -.202   .117                .****I    .                    14.493   .489
 16  -.213   .115                .****I    .                    17.907   .329

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  48     Computable first lags:  47
```

```
Partial Autocorrelations:    MFH

   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75 -.5 -.25   0   .25  .5   .75   1
                  +----+----+----+----+----+----+----+----+
  1   .311   .144               .     I******
  2  -.006   .144               .     *     .
  3  -.018   .144               .     *     .
  4  -.003   .144               .     *     .
  5  -.028   .144               .    *I     .
  6   .074   .144               .     I*    .
  7  -.109   .144               .   **I     .
  8  -.074   .144               .    *I     .
  9  -.132   .144               .  ***I     .
 10   .020   .144               .     *     .
 11   .165   .144               .     I***  .
 12  -.159   .144               .  ***I     .
 13  -.071   .144               .    *I     .
 14  -.068   .144               .    *I     .
 15  -.155   .144               .  ***I     .
 16  -.134   .144               .  ***I     .

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  48     Computable first lags:  47
```


MFH
1.0
.5
0.0
-.5
-1.0
ACF
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Lag Number
Confidence Limits
Coefficient


MFH
1.0
.5
0.0
-.5
-1.0
Partial ACF
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Lag Number
Confidence Limits
Coefficient

Runs Test Results

NOMENCLATURE	MC	MFH
Test Value (Median)	83.050	22.700
Cases < Test Value	24	24
Cases ≥ Test Value	24	24
Total Cases	48	48
Number of Runs	14	20
Z Score	-3.064	-1.313
Asymptotic Significance	.002	.189

APPENDIX G: Correlation Data

1. Spearman Rho and Kendall Tau b Results for all Variables

Nonparametric Measures of Association

Variable	by Variable	Spearman Rho	Prob>|Rho|
MC	POSS	-0.0999	0.4993
NMCM	POSS	0.1971	0.1794
NMCM	MC	-0.9595	<.0001
NMCS	POSS	-0.0663	0.6542
NMCS	MC	-0.8397	<.0001
NMCS	NMCM	0.7018	<.0001
ASE	POSS	-0.1501	0.3087
ASE	MC	0.7681	<.0001
ASE	NMCM	-0.8191	<.0001
ASE	NMCS	-0.5286	0.0001
CLT	POSS	0.0746	0.6145
CLT	MC	-0.5587	<.0001
CLT	NMCM	0.5624	<.0001
CLT	NMCS	0.3865	0.0067
CLT	ASE	-0.7388	<.0001
GA	POSS	-0.0525	0.7231
GA	MC	-0.3946	0.0055
GA	NMCM	0.4144	0.0034
GA	NMCS	0.2705	0.0629
GA	ASE	-0.5034	0.0003
GA	CLT	0.3153	0.0291
AA	POSS	0.3958	0.0054
AA	MC	-0.2498	0.0869
AA	NMCM	0.2918	0.0442
AA	NMCS	0.1140	0.4402
AA	ASE	-0.2376	0.1040
AA	CLT	0.1866	0.2042
AA	GA	0.0872	0.5557
MCX	POSS	0.1152	0.4356
MCX	MC	-0.7654	<.0001
MCX	NMCM	0.7954	<.0001
MCX	NMCS	0.5892	<.0001
MCX	ASE	-0.8028	<.0001
MCX	CLT	0.4791	0.0006
MCX	GA	0.3757	0.0085
MCX	AA	0.1923	0.1903
CANN	POSS	-0.4457	0.0015
CANN	MC	-0.1995	0.1739
CANN	NMCM	0.1260	0.3933
CANN	NMCS	0.3357	0.0197
CANN	ASE	-0.1862	0.2052
CANN	CLT	0.2430	0.0961
CANN	GA	0.1618	0.2718
CANN	AA	-0.4007	0.0048
CANN	MCX	0.1457	0.3232
BRK	POSS	0.0994	0.5016
BRK	MC	-0.7280	<.0001
BRK	NMCM	0.7595	<.0001
BRK	NMCS	0.4380	0.0018
BRK	ASE	-0.6863	<.0001
BRK	CLT	0.4783	0.0006

BRK	GA	0.3581	0.0124
BRK	AA	0.3230	0.0251
BRK	MCX	0.6796	<.0001
BRK	CANN	0.1135	0.4425
FIX	POSS	-0.1607	0.2752
FIX	MC	0.4614	0.0010
FIX	NMCM	-0.5252	0.0001
FIX	NMCS	-0.2098	0.1524
FIX	ASE	0.4783	0.0006
FIX	CLT	-0.3575	0.0126
FIX	GA	-0.0709	0.6318
FIX	AA	-0.2587	0.0759
FIX	MCX	-0.4439	0.0016
FIX	CANN	-0.1101	0.4563
FIX	BRK	-0.4784	0.0006
REP	POSS	0.1797	0.2217
REP	MC	-0.2794	0.0544
REP	NMCM	0.3343	0.0202
REP	NMCS	0.1776	0.2273
REP	ASE	-0.3621	0.0114
REP	CLT	0.1757	0.2323
REP	GA	0.2475	0.0898
REP	AA	0.0409	0.7827
REP	MCX	0.5575	<.0001
REP	CANN	-0.2062	0.1596
REP	BRK	0.3210	0.0261
REP	FIX	-0.1285	0.3841
REC	POSS	0.2749	0.0586
REC	MC	-0.1833	0.2123
REC	NMCM	0.2176	0.1373
REC	NMCS	0.0806	0.5859
REC	ASE	-0.3739	0.0089
REC	CLT	0.3020	0.0369
REC	GA	0.2482	0.0890
REC	AA	0.1900	0.1958
REC	MCX	0.2950	0.0418
REC	CANN	-0.2302	0.1155
REC	BRK	0.2279	0.1193
REC	FIX	0.1109	0.4532
REC	REP	0.4769	0.0006
DD	POSS	0.3704	0.0096
DD	MC	-0.6732	<.0001
DD	NMCM	0.7570	<.0001
DD	NMCS	0.4588	0.0010
DD	ASE	-0.7291	<.0001
DD	CLT	0.3345	0.0201
DD	GA	0.2475	0.0899
DD	AA	0.4707	0.0007
DD	MCX	0.7035	<.0001
DD	CANN	-0.1797	0.2216
DD	BRK	0.6223	<.0001
DD	FIX	-0.4592	0.0010
DD	REP	0.4968	0.0003
DD	REC	0.3656	0.0106
PHUT	POSS	0.1156	0.4339
PHUT	MC	-0.4735	0.0007
PHUT	NMCM	0.5547	<.0001
PHUT	NMCS	0.2171	0.1382
PHUT	ASE	-0.6003	<.0001
PHUT	CLT	0.4043	0.0044

PHUT	GA	0.1777	0.2269
PHUT	AA	0.1653	0.2616
PHUT	MCX	0.4694	0.0008
PHUT	CANN	0.0434	0.7698
PHUT	BRK	0.4688	0.0008
PHUT	FIX	-0.3051	0.0350
PHUT	REP	0.2024	0.1677
PHUT	REC	0.3539	0.0136
PHUT	DD	0.5234	0.0001
PSUT	POSS	0.3928	0.0058
PSUT	MC	-0.3227	0.0253
PSUT	NMCM	0.4256	0.0026
PSUT	NMCS	0.1700	0.2482
PSUT	ASE	-0.4011	0.0047
PSUT	CLT	0.1584	0.2821
PSUT	GA	0.0596	0.6875
PSUT	AA	0.2096	0.1528
PSUT	MCX	0.3672	0.0102
PSUT	CANN	-0.2385	0.1026
PSUT	BRK	0.2417	0.0980
PSUT	FIX	-0.1879	0.2010
PSUT	REP	0.4098	0.0038
PSUT	REC	0.3407	0.0178
PSUT	DD	0.5706	<.0001
PSUT	PHUT	0.6926	<.0001
AHUT	POSS	0.4081	0.0040
AHUT	MC	-0.2447	0.0937
AHUT	NMCM	0.3287	0.0226
AHUT	NMCS	0.1147	0.4375
AHUT	ASE	-0.2967	0.0406
AHUT	CLT	0.1951	0.1840
AHUT	GA	-0.0309	0.8348
AHUT	AA	0.2748	0.0587
AHUT	MCX	0.3304	0.0218
AHUT	CANN	-0.4206	0.0029
AHUT	BRK	0.1958	0.1824
AHUT	FIX	0.0376	0.7999
AHUT	REP	0.4511	0.0013
AHUT	REC	0.4354	0.0020
AHUT	DD	0.5509	<.0001
AHUT	PHUT	0.5167	0.0002
AHUT	PSUT	0.7423	<.0001
ASUT	POSS	0.5662	<.0001
ASUT	MC	0.0521	0.7249
ASUT	NMCM	0.0453	0.7598
ASUT	NMCS	-0.1387	0.3471
ASUT	ASE	0.0451	0.7609
ASUT	CLT	-0.1731	0.2394
ASUT	GA	-0.1107	0.4536
ASUT	AA	0.2898	0.0458
ASUT	MCX	0.0462	0.7553
ASUT	CANN	-0.6045	<.0001
ASUT	BRK	-0.0521	0.7252
ASUT	FIX	0.1518	0.3031
ASUT	REP	0.3279	0.0229
ASUT	REC	0.2828	0.0514
ASUT	DD	0.3508	0.0145
ASUT	PHUT	0.2903	0.0453
ASUT	PSUT	0.6784	<.0001
ASUT	AHUT	0.8200	<.0001

MEFF	POSS	-0.1847	0.2089
MEFF	MC	0.0806	0.5858
MEFF	NMCM	-0.0380	0.7976
MEFF	NMCS	-0.1584	0.2823
MEFF	ASE	0.0488	0.7419
MEFF	CLT	0.0002	0.9990
MEFF	GA	-0.1865	0.2043
MEFF	AA	0.0486	0.7430
MEFF	MCX	0.0610	0.6804
MEFF	CANN	0.1626	0.2696
MEFF	BRK	0.0956	0.5181
MEFF	FIX	-0.0558	0.7061
MEFF	REP	-0.0613	0.6789
MEFF	REC	-0.0795	0.5910
MEFF	DD	-0.1238	0.4019
MEFF	PHUT	-0.0833	0.5736
MEFF	PSUT	-0.1519	0.3026
MEFF	AHUT	-0.2001	0.1727
MEFF	ASUT	-0.1937	0.1871
MFH	POSS	-0.0676	0.6478
MFH	MC	0.0649	0.6611
MFH	NMCM	-0.1160	0.4325
MFH	NMCS	0.0602	0.6843
MFH	ASE	0.0838	0.5713
MFH	CLT	-0.2022	0.1681
MFH	GA	0.1160	0.4323
MFH	AA	-0.1360	0.3567
MFH	MCX	-0.0061	0.9674
MFH	CANN	0.1228	0.4057
MFH	BRK	-0.2620	0.0720
MFH	FIX	0.0413	0.7806
MFH	REP	-0.0599	0.6858
MFH	REC	-0.1501	0.3084
MFH	DD	-0.2423	0.0970
MFH	PHUT	-0.2078	0.1565
MFH	PSUT	-0.1253	0.3963
MFH	AHUT	-0.2371	0.1047
MFH	ASUT	-0.1423	0.3345
MFH	MEFF	-0.1602	0.2768

Variable	by Variable	Kendall Tau b	Prob>|Tau b|
MC	POSS	-0.0378	0.7085
NMCM	POSS	0.1086	0.2815
NMCM	MC	-0.8437	0.0000
NMCS	POSS	-0.0549	0.5870
NMCS	MC	-0.6625	<.0001
NMCS	NMCM	0.5174	<.0001
ASE	POSS	-0.0986	0.3276
ASE	MC	0.5730	<.0001
ASE	NMCM	-0.6116	<.0001
ASE	NMCS	-0.3804	0.0001
CLT	POSS	0.0414	0.6821
CLT	MC	-0.3900	0.0001
CLT	NMCM	0.3722	0.0002
CLT	NMCS	0.2750	0.0063
CLT	ASE	-0.5544	<.0001
GA	POSS	-0.0498	0.6242
GA	MC	-0.2843	0.0049

GA	NMCM	0.2962	0.0033
GA	NMCS	0.1820	0.0721
GA	ASE	-0.3344	0.0009
GA	CLT	0.1983	0.0502
AA	POSS	0.2886	0.0044
AA	MC	-0.1647	0.1017
AA	NMCM	0.1974	0.0493
AA	NMCS	0.0744	0.4602
AA	ASE	-0.1659	0.0981
AA	CLT	0.1094	0.2777
AA	GA	0.0740	0.4654
MCX	POSS	0.0782	0.4469
MCX	MC	-0.5907	<.0001
MCX	NMCM	0.6086	<.0001
MCX	NMCS	0.4224	<.0001
MCX	ASE	-0.6178	<.0001
MCX	CLT	0.3393	0.0009
MCX	GA	0.2843	0.0057
MCX	AA	0.1382	0.1769
CANN	POSS	-0.3119	0.0020
CANN	MC	-0.1419	0.1573
CANN	NMCM	0.0962	0.3369
CANN	NMCS	0.2163	0.0313
CANN	ASE	-0.1325	0.1853
CANN	CLT	0.1547	0.1238
CANN	GA	0.1115	0.2697
CANN	AA	-0.2998	0.0029
CANN	MCX	0.1031	0.3124
BRK	POSS	0.0413	0.6822
BRK	MC	-0.5477	<.0001
BRK	NMCM	0.5812	<.0001
BRK	NMCS	0.3082	0.0021
BRK	ASE	-0.4907	<.0001
BRK	CLT	0.3271	0.0011
BRK	GA	0.2562	0.0112
BRK	AA	0.2236	0.0262
BRK	MCX	0.5163	<.0001
BRK	CANN	0.0687	0.4935
FIX	POSS	-0.1041	0.3019
FIX	MC	0.3316	0.0009
FIX	NMCM	-0.3815	0.0001
FIX	NMCS	-0.1419	0.1573
FIX	ASE	0.3410	0.0006
FIX	CLT	-0.2339	0.0198
FIX	GA	-0.0314	0.7554
FIX	AA	-0.1707	0.0894
FIX	MCX	-0.3254	0.0014
FIX	CANN	-0.0775	0.4392
FIX	BRK	-0.3437	0.0006
REP	POSS	0.1358	0.1840
REP	MC	-0.1883	0.0639
REP	NMCM	0.2104	0.0380
REP	NMCS	0.1296	0.2026
REP	ASE	-0.2399	0.0178
REP	CLT	0.1287	0.2058
REP	GA	0.1487	0.1462
REP	AA	0.0345	0.7349
REP	MCX	0.4119	<.0001
REP	CANN	-0.1402	0.1673
REP	BRK	0.2152	0.0340

REP	FIX	-0.0949	0.3497
REC	POSS	0.2057	0.0447
REC	MC	-0.1098	0.2808
REC	NMCM	0.1222	0.2289
REC	NMCS	0.0591	0.5622
REC	ASE	-0.2659	0.0088
REC	CLT	0.2200	0.0310
REC	GA	0.1719	0.0935
REC	AA	0.1392	0.1725
REC	MCX	0.1977	0.0563
REC	CANN	-0.1733	0.0887
REC	BRK	0.1505	0.1390
REC	FIX	0.0770	0.4487
REC	REP	0.3468	0.0008
DD	POSS	0.2490	0.0137
DD	MC	-0.4864	<.0001
DD	NMCM	0.5450	<.0001
DD	NMCS	0.3235	0.0013
DD	ASE	-0.4989	<.0001
DD	CLT	0.2173	0.0307
DD	GA	0.1925	0.0568
DD	AA	0.3284	0.0011
DD	MCX	0.5339	<.0001
DD	CANN	-0.1070	0.2859
DD	BRK	0.4574	<.0001
DD	FIX	-0.3091	0.0020
DD	REP	0.3402	0.0008
DD	REC	0.2404	0.0182
PHUT	POSS	0.0664	0.5102
PHUT	MC	-0.3224	0.0013
PHUT	NMCM	0.3758	0.0002
PHUT	NMCS	0.1489	0.1375
PHUT	ASE	-0.4082	<.0001
PHUT	CLT	0.2819	0.0049
PHUT	GA	0.1283	0.2032
PHUT	AA	0.1125	0.2625
PHUT	MCX	0.3196	0.0017
PHUT	CANN	0.0258	0.7965
PHUT	BRK	0.3078	0.0021
PHUT	FIX	-0.2258	0.0239
PHUT	REP	0.1282	0.2060
PHUT	REC	0.2426	0.0169
PHUT	DD	0.3605	0.0003
PSUT	POSS	0.2760	0.0067
PSUT	MC	-0.1974	0.0512
PSUT	NMCM	0.2716	0.0072
PSUT	NMCS	0.1218	0.2293
PSUT	ASE	-0.2560	0.0112
PSUT	CLT	0.0966	0.3407
PSUT	GA	0.0291	0.7755
PSUT	AA	0.1473	0.1466
PSUT	MCX	0.2258	0.0283
PSUT	CANN	-0.1676	0.0977
PSUT	BRK	0.1630	0.1071
PSUT	FIX	-0.1341	0.1847
PSUT	REP	0.2814	0.0060
PSUT	REC	0.2373	0.0208
PSUT	DD	0.4072	<.0001
PSUT	PHUT	0.5537	<.0001
AHUT	POSS	0.2706	0.0074

AHUT	MC	-0.1651	0.0999
AHUT	NMCM	0.2155	0.0314
AHUT	NMCS	0.0929	0.3549
AHUT	ASE	-0.1948	0.0515
AHUT	CLT	0.1207	0.2298
AHUT	GA	-0.0297	0.7690
AHUT	AA	0.1888	0.0605
AHUT	MCX	0.2309	0.0237
AHUT	CANN	-0.2837	0.0047
AHUT	BRK	0.1311	0.1911
AHUT	FIX	0.0045	0.9645
AHUT	REP	0.3230	0.0015
AHUT	REC	0.3130	0.0021
AHUT	DD	0.3880	0.0001
AHUT	PHUT	0.3961	<.0001
AHUT	PSUT	0.5910	<.0001
ASUT	POSS	0.4206	<.0001
ASUT	MC	0.0314	0.7554
ASUT	NMCM	0.0287	0.7759
ASUT	NMCS	-0.0737	0.4655
ASUT	ASE	0.0385	0.7021
ASUT	CLT	-0.1143	0.2583
ASUT	GA	-0.0923	0.3637
ASUT	AA	0.2188	0.0305
ASUT	MCX	0.0266	0.7953
ASUT	CANN	-0.4417	<.0001
ASUT	BRK	-0.0386	0.7020
ASUT	FIX	0.0834	0.4080
ASUT	REP	0.2285	0.0253
ASUT	REC	0.2109	0.0394
ASUT	DD	0.2603	0.0099
ASUT	PHUT	0.2105	0.0366
ASUT	PSUT	0.5249	<.0001
ASUT	AHUT	0.6284	<.0001
MEFF	POSS	-0.1360	0.1942
MEFF	MC	0.0538	0.6051
MEFF	NMCM	-0.0377	0.7168
MEFF	NMCS	-0.1116	0.2843
MEFF	ASE	0.0254	0.8066
MEFF	CLT	0.0189	0.8560
MEFF	GA	-0.1237	0.2379
MEFF	AA	0.0294	0.7785
MEFF	MCX	0.0454	0.6682
MEFF	CANN	0.1142	0.2723
MEFF	BRK	0.0736	0.4792
MEFF	FIX	-0.0349	0.7372
MEFF	REP	-0.0373	0.7231
MEFF	REC	-0.0538	0.6107
MEFF	DD	-0.0680	0.5137
MEFF	PHUT	-0.0593	0.5677
MEFF	PSUT	-0.1106	0.2921
MEFF	AHUT	-0.1548	0.1368
MEFF	ASUT	-0.1472	0.1595
MFH	POSS	-0.0360	0.7217
MFH	MC	0.0492	0.6246
MFH	NMCM	-0.0759	0.4497
MFH	NMCS	0.0349	0.7286
MFH	ASE	0.0766	0.4444
MFH	CLT	-0.1362	0.1762
MFH	GA	0.0820	0.4179

MFH	AA	-0.0942	0.3502
MFH	MCX	-0.0082	0.9359
MFH	CANN	0.0796	0.4285
MFH	BRK	-0.1787	0.0752
MFH	FIX	0.0268	0.7896
MFH	REP	-0.0453	0.6560
MFH	REC	-0.0909	0.3726
MFH	DD	-0.1654	0.0998
MFH	PHUT	-0.1534	0.1261
MFH	PSUT	-0.0930	0.3590
MFH	AHUT	-0.1672	0.0962
MFH	ASUT	-0.0891	0.3782
MFH	MEFF	-0.1135	0.2762

2. Variables that exhibited significant correlation by Spearman Rho measure

Variable	by Variable	Spearman Rho	Prob>|Rho|
AA	NMCM	0.2918	0.0442
AA	POSS	0.3958	0.0054
AHUT	ASE	-0.2967	0.0406
AHUT	CANN	-0.4206	0.0029
AHUT	DD	0.5509	<.0001
AHUT	MCX	0.3304	0.0218
AHUT	NMCM	0.3287	0.0226
AHUT	PHUT	0.5167	0.0002
AHUT	POSS	0.4081	0.004
AHUT	PSUT	0.7423	<.0001
AHUT	REC	0.4354	0.002
AHUT	REP	0.4511	0.0013
ASE	MC	0.7681	<.0001
ASE	NMCM	-0.8191	<.0001
ASE	NMCS	-0.5286	0.0001
ASUT	AA	0.2898	0.0458
ASUT	AHUT	0.82	<.0001
ASUT	CANN	-0.6045	<.0001
ASUT	DD	0.3508	0.0145
ASUT	PHUT	0.2903	0.0453
ASUT	POSS	0.5662	<.0001
ASUT	PSUT	0.6784	<.0001
ASUT	REP	0.3279	0.0229
BRK	AA	0.323	0.0251
BRK	ASE	-0.6863	<.0001
BRK	CLT	0.4783	0.0006
BRK	GA	0.3581	0.0124
BRK	MC	-0.728	<.0001
BRK	MCX	0.6796	<.0001
BRK	NMCM	0.7595	<.0001

BRK	NMCS	0.438	0.0018
CANN	AA	-0.4007	0.0048
CANN	NMCS	0.3357	0.0197
CANN	POSS	-0.4457	0.0015
CLT	ASE	-0.7388	<.0001
CLT	MC	-0.5587	<.0001
CLT	NMCM	0.5624	<.0001
CLT	NMCS	0.3865	0.0067
DD	AA	0.4707	0.0007
DD	ASE	-0.7291	<.0001
DD	BRK	0.6223	<.0001
DD	CLT	0.3345	0.0201
DD	FIX	-0.4592	0.001
DD	MC	-0.6732	<.0001
DD	MCX	0.7035	<.0001
DD	NMCM	0.757	<.0001
DD	NMCS	0.4588	0.001
DD	POSS	0.3704	0.0096
DD	REC	0.3656	0.0106
DD	REP	0.4968	0.0003
FIX	ASE	0.4783	0.0006
FIX	BRK	-0.4784	0.0006
FIX	CLT	-0.3575	0.0126
FIX	MC	0.4614	0.001
FIX	MCX	-0.4439	0.0016
FIX	NMCM	-0.5252	0.0001
GA	ASE	-0.5034	0.0003
GA	CLT	0.3153	0.0291
GA	MC	-0.3946	0.0055
GA	NMCM	0.4144	0.0034
MCX	ASE	-0.8028	<.0001
MCX	CLT	0.4791	0.0006
MCX	GA	0.3757	0.0085
MCX	MC	-0.7654	<.0001
MCX	NMCM	0.7954	<.0001
MCX	NMCS	0.5892	<.0001
NMCM	MC	-0.9595	<.0001
NMCS	MC	-0.8397	<.0001
NMCS	NMCM	0.7018	<.0001
PHUT	ASE	-0.6003	<.0001
PHUT	BRK	0.4688	0.0008
PHUT	CLT	0.4043	0.0044
PHUT	DD	0.5234	0.0001
PHUT	FIX	-0.3051	0.035

PHUT	MC	-0.4735	0.0007
PHUT	MCX	0.4694	0.0008
PHUT	NMCM	0.5547	<.0001
PHUT	REC	0.3539	0.0136
PSUT	ASE	-0.4011	0.0047
PSUT	DD	0.5706	<.0001
PSUT	MC	-0.3227	0.0253
PSUT	MCX	0.3672	0.0102
PSUT	NMCM	0.4256	0.0026
PSUT	PHUT	0.6926	<.0001
PSUT	POSS	0.3928	0.0058
PSUT	REC	0.3407	0.0178
PSUT	REP	0.4098	0.0038
REC	ASE	-0.3739	0.0089
REC	CLT	0.302	0.0369
REC	MCX	0.295	0.0418
REC	REP	0.4769	0.0006
REP	ASE	-0.3621	0.0114
REP	BRK	0.321	0.0261
REP	MCX	0.5575	<.0001
REP	NMCM	0.3343	0.0202

3. Variables that exhibited significant correlation by Kendall Tau b measure

Variable	**by Variable**	**Kendall Tau b**	**Prob>|Tau b|**
AA	NMCM	0.1974	0.0493
AA	POSS	0.2886	0.0044
AHUT	CANN	-0.2837	0.0047
AHUT	DD	0.388	0.0001
AHUT	MCX	0.2309	0.0237
AHUT	NMCM	0.2155	0.0314
AHUT	PHUT	0.3961	<.0001
AHUT	POSS	0.2706	0.0074
AHUT	PSUT	0.591	<.0001
AHUT	REC	0.313	0.0021
AHUT	REP	0.323	0.0015
ASE	MC	0.573	<.0001
ASE	NMCM	-0.6116	<.0001
ASE	NMCS	-0.3804	0.0001
ASUT	AA	0.2188	0.0305
ASUT	AHUT	0.6284	<.0001
ASUT	CANN	-0.4417	<.0001
ASUT	DD	0.2603	0.0099

ASUT	PHUT	0.2105	0.0366
ASUT	POSS	0.4206	<.0001
ASUT	PSUT	0.5249	<.0001
ASUT	REC	0.2109	0.0394
ASUT	REP	0.2285	0.0253
BRK	AA	0.2236	0.0262
BRK	ASE	-0.4907	<.0001
BRK	CLT	0.3271	0.0011
BRK	GA	0.2562	0.0112
BRK	MC	-0.5477	<.0001
BRK	MCX	0.5163	<.0001
BRK	NMCM	0.5812	<.0001
BRK	NMCS	0.3082	0.0021
CANN	AA	-0.2998	0.0029
CANN	NMCS	0.2163	0.0313
CANN	POSS	-0.3119	0.002
CLT	ASE	-0.5544	<.0001
CLT	MC	-0.39	0.0001
CLT	NMCM	0.3722	0.0002
CLT	NMCS	0.275	0.0063
DD	AA	0.3284	0.0011
DD	ASE	-0.4989	<.0001
DD	BRK	0.4574	<.0001
DD	CLT	0.2173	0.0307
DD	FIX	-0.3091	0.002
DD	MC	-0.4864	<.0001
DD	MCX	0.5339	<.0001
DD	NMCM	0.545	<.0001
DD	NMCS	0.3235	0.0013
DD	POSS	0.249	0.0137
DD	REC	0.2404	0.0182
DD	REP	0.3402	0.0008
FIX	ASE	0.341	0.0006
FIX	BRK	-0.3437	0.0006
FIX	CLT	-0.2339	0.0198
FIX	MC	0.3316	0.0009
FIX	MCX	-0.3254	0.0014
FIX	NMCM	-0.3815	0.0001
GA	ASE	-0.3344	0.0009
GA	MC	-0.2843	0.0049
GA	NMCM	0.2962	0.0033
MCX	ASE	-0.6178	<.0001
MCX	CLT	0.3393	0.0009
MCX	GA	0.2843	0.0057

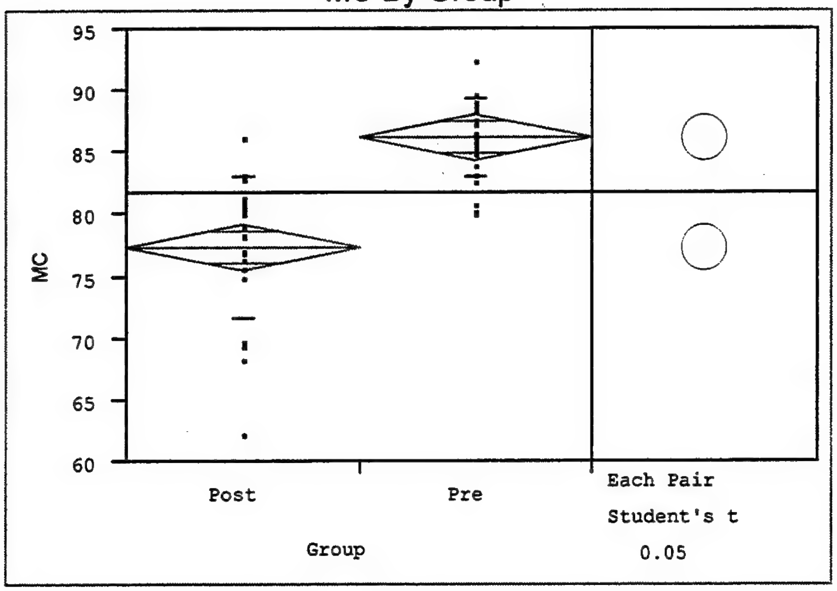
MCX	MC	-0.5907	<.0001
MCX	NMCM	0.6086	<.0001
MCX	NMCS	0.4224	<.0001
NMCM	MC	-0.8437	0
NMCS	MC	-0.6625	<.0001
NMCS	NMCM	0.5174	<.0001
PHUT	ASE	-0.4082	<.0001
PHUT	BRK	0.3078	0.0021
PHUT	CLT	0.2819	0.0049
PHUT	DD	0.3605	0.0003
PHUT	FIX	-0.2258	0.0239
PHUT	MC	-0.3224	0.0013
PHUT	MCX	0.3196	0.0017
PHUT	NMCM	0.3758	0.0002
PHUT	REC	0.2426	0.0169
PSUT	ASE	-0.256	0.0112
PSUT	DD	0.4072	<.0001
PSUT	MCX	0.2258	0.0283
PSUT	NMCM	0.2716	0.0072
PSUT	PHUT	0.5537	<.0001
PSUT	POSS	0.276	0.0067
PSUT	REC	0.2373	0.0208
PSUT	REP	0.2814	0.006
REC	ASE	-0.2659	0.0088
REC	CLT	0.22	0.031
REC	POSS	0.2057	0.0447
REC	REP	0.3468	0.0008
REP	ASE	-0.2399	0.0178
REP	BRK	0.2152	0.034
REP	MCX	0.4119	<.0001
REP	NMCM	0.2104	0.038

4. Variables that were not common to both lists

Variable	By Variable	Measure	P Value
AHUT	ASE	Kendall Tau b	.0515
ASUT	REC	Spearman Rho	.0514
GA	CLT	Kendall Tau b	.0502
PSUT	MC	Kendall Tau b	.0512
REC	MCX	Kendall Tau b	.0563

APPENDIX H: Means Comparison Results

MC By Group



Oneway Anova
Summary of Fit

RSquare	0.475374
RSquare Adj	0.463969
Root Mean Square Error	4.672551
Mean of Response	81.83333
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	910.0208	910.021	41.6815
Error	46	1004.3058	21.833	Prob>F
C Total	47	1914.3267	40.730	<.0001

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	77.4792	0.95378
Pre	24	86.1875	0.95378

Std Error uses a pooled estimate of error variance

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	5.802771	4.465972	4.295833
Pre	24	3.161221	2.488542	2.487500

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.5882	1	46	0.0375
Brown-Forsythe	3.9270	1	46	0.0535
Levene	5.7253	1	46	0.0209
Bartlett	7.8390	1	?	0.0051

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
41.6815	1	35.547	<.0001
t-Test			
6.4561			

Means Comparisons

Dif=Mean[i]-Mean[j]	Pre	Post
Pre	0.00000	8.70833
Post	-8.70833	0.00000

Alpha= 0.05

Comparisons for each pair using Student's t

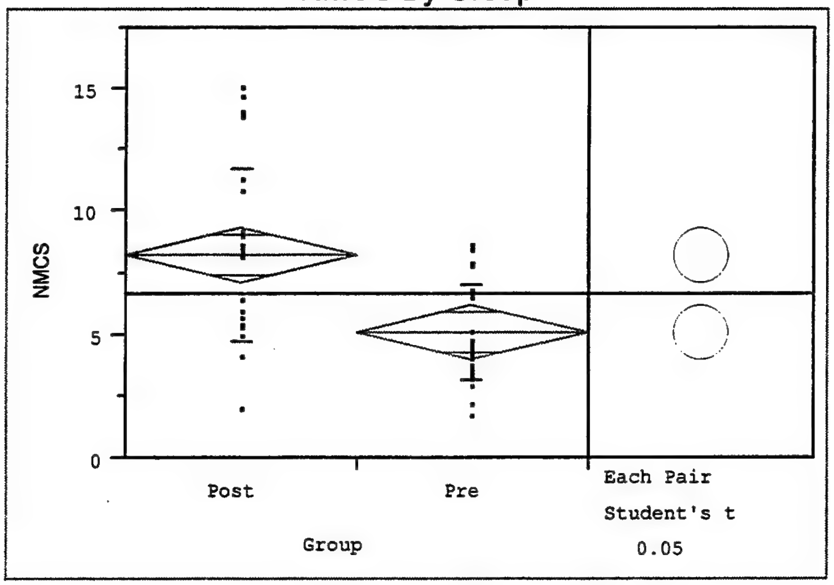
t

2.01289

Abs(Dif)-LSD	Pre	Post
Pre	-2.71508	5.99325
Post	5.99325	-2.71508

Positive values show pairs of means that are significantly different.

NMCS By Group



Oneway Anova
Summary of Fit

RSquare	0.233941
RSquare Adj	0.217288
Root Mean Square Error	2.880579
Mean of Response	6.645833
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	116.56333	116.563	14.0476
Error	46	381.69583	8.298	Prob>F
C Total	47	498.25917	10.601	0.0005

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	8.20417	0.58800
Pre	24	5.08750	0.58800

Std Error uses a pooled estimate of error variance

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	3.570103	2.837847	2.837500
Pre	24	1.962100	1.626042	1.529167

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	6.8350	1	46	0.0120
Brown-Forsythe	6.0266	1	46	0.0179
Levene	6.4869	1	46	0.0143
Bartlett	7.6254	1	?	0.0058

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
14.0476	1	35.733	0.0006
t-Test			
3.7480			

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Post	24	750.5	31.2708	3.342
Pre	24	425.5	17.7292	-3.342

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
425.5	-3.34174	0.0008

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
11.2363	1	0.0008

Means Comparisons

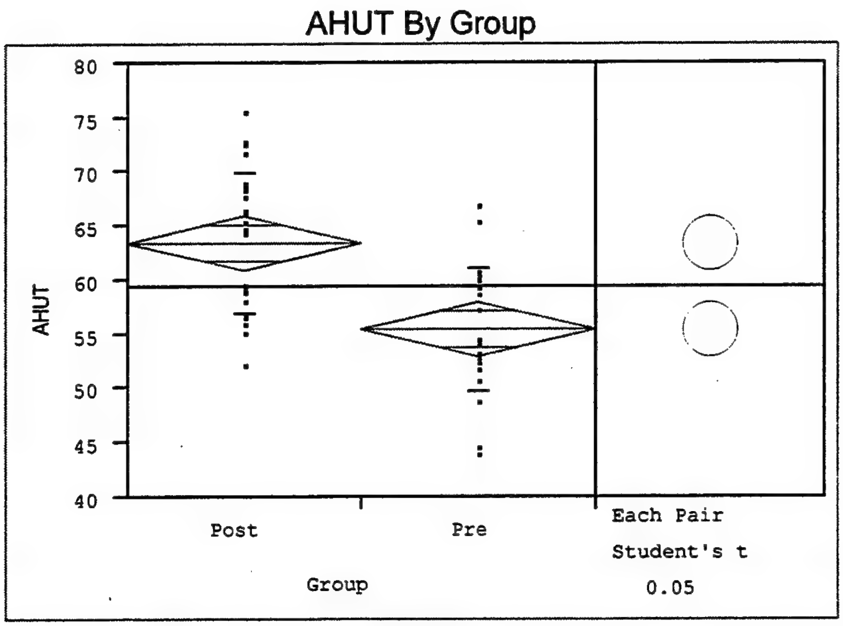
Dif=Mean[i]-Mean[j]	Post	Pre
Post	0.00000	3.11667
Pre	-3.11667	0.00000

Alpha=	0.05

Comparisons for each pair using Student's t

	t	
	2.01289	
Abs(Dif)-LSD	Post	Pre
Post	-1.67382	1.44285
Pre	1.44285	-1.67382

Positive values show pairs of means that are significantly different.



Oneway Anova
Summary of Fit

RSquare	0.306455
RSquare Adj	0.291378
Root Mean Square Error	6.217329
Mean of Response	59.49583
Observations (or Sum Wgts)	48

	t-Test Difference	t-Test	DF	Prob>|t|
Estimate	8.0917	4.508	46	<.0001
Std Error	1.7948			
Lower 95%	4.4790			
Upper 95%	11.7044			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	785.7008	785.701	20.3259
Error	46	1778.1383	38.655	Prob>F
C Total	47	2563.8392	54.550	<.0001

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	63.5417	1.2691
Pre	24	55.4500	1.2691

Std Error uses a pooled estimate of error variance

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	6.683394	5.863194	5.783333
Pre	24	5.713371	4.616667	4.450000

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.9192	1	46	0.3427
Brown-Forsythe	1.6527	1	46	0.2050
Levene	1.9425	1	46	0.1701
Bartlett	0.5513	1	?	0.4578

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
20.3259	1	44.913	<.0001
t-Test			
4.5084			

Means Comparisons

Dif=Mean[i]-Mean[j]	Post	Pre
Post	0.00000	8.09167
Pre	-8.09167	0.00000

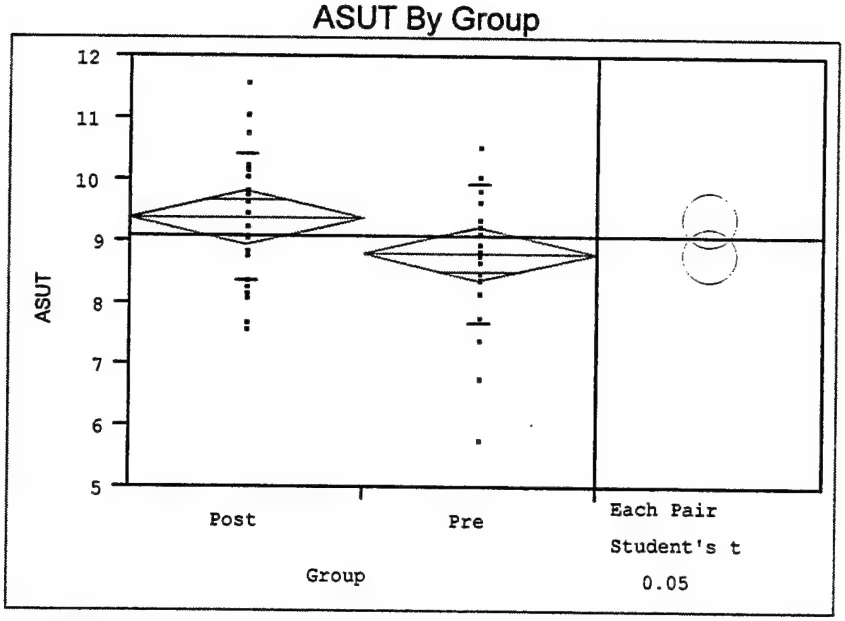
Alpha= 0.05

Comparisons for each pair using Student's t

	t	
	2.01289	
Abs(Dif)-LSD	Post	Pre
Post	-3.61271	4.47896
Pre	4.47896	-3.61271

Positive values show pairs of means that are significantly different.

ASUT By Group



Oneway Anova
Summary of Fit

RSquare	0.072761
RSquare Adj	0.052604
Root Mean Square Error	1.093981
Mean of Response	9.1125
Observations (or Sum Wgts)	48

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	0.60000	1.900	46	0.0637
Std Error	0.31580			
Lower 95%	-0.03568			
Upper 95%	1.23568			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.320000	4.32000	3.6096
Error	46	55.052500	1.19679	Prob>F
C Total	47	59.372500	1.26324	0.0637

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	9.41250	0.22331
Pre	24	8.81250	0.22331

Std Error uses a pooled estimate of error variance

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	1.033909	0.8104167	0.7958333
Pre	24	1.150921	0.8604167	0.8375000

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.2380	1	46	0.6280
Brown-Forsythe	0.0399	1	46	0.8426
Levene	0.0641	1	46	0.8012
Bartlett	0.2583	1	?	0.6113

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.6096	1	45.481	0.0638
t-Test			
1.8999			

Means Comparisons

Dif=Mean[i]-Mean[j]	Post	Pre
Post	0.000000	0.600000
Pre	-0.6	0.000000

Alpha= 0.05

Comparisons for each pair using Student's t

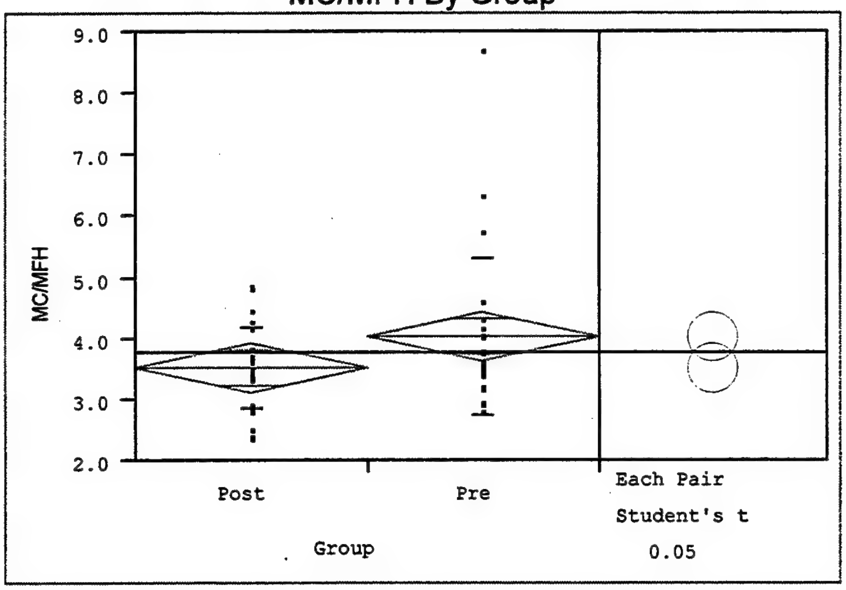
t

2.01289

Abs(Dif)-LSD	Post	Pre
Post	-0.63568	-0.03568
Pre	-0.03568	-0.63568

Positive values show pairs of means that are significantly different.

MC/MFH By Group



Oneway Anova
Summary of Fit

RSquare	0.058968
RSquare Adj	0.038511
Root Mean Square Error	1.040719
Mean of Response	3.774547
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.122025	3.12202	2.8825
Error	46	49.822436	1.08310	Prob>F
C Total	47	52.944461	1.12648	0.0963

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	3.51951	0.21244
Pre	24	4.02958	0.21244

Std Error uses a pooled estimate of error variance

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Post	24	522.5	21.7708	-1.340
Pre	24	653.5	27.2292	1.340

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
653.5	1.34031	0.1801

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
1.8242	1	0.1768

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	0.695810	0.5198074	0.5198074
Pre	24	1.296936	0.8260360	0.7400221

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	1.4663	1	46	0.2321
Brown-Forsythe	0.7871	1	46	0.3796
Levene	1.9199	1	46	0.1725
Bartlett	8.2163	1	?	0.0042

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
2.8825	1	35.227	0.0984
t-Test			
1.6978			

Means Comparisons

Dif=Mean[i]-Mean[j]	Pre	Post
Pre	0.000000	0.510067
Post	-0.51007	0.000000

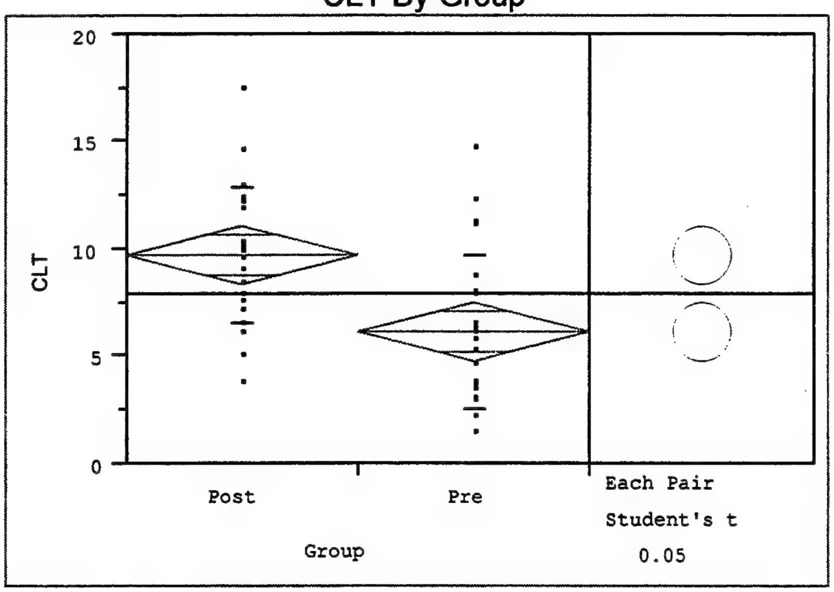
Alpha= 0.05

Comparisons for each pair using Student's t

	t	
	2.01289	
Abs(Dif)-LSD	Pre	Post
Pre	-0.60473	-0.09466
Post	-0.09466	-0.60473

Positive values show pairs of means that are significantly different.

CLT By Group



Oneway Anova

Summary of Fit

RSquare	0.229419
RSquare Adj	0.212667
Root Mean Square Error	3.389336
Mean of Response	7.939583
Observations (or Sum Wgts)	48

t-Test

	Difference	t-Test	DF	Prob>|t|
Estimate	3.62083	3.701	46	0.0006
Std Error	0.97842			
Lower 95%	1.65139			
Upper 95%	5.59028			

Assuming equal variances

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	157.32521	157.325	13.6952
Error	46	528.42958	11.488	Prob>F
C Total	47	685.75479	14.591	0.0006

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	9.75000	0.69185
Pre	24	6.12917	0.69185

Std Error uses a pooled estimate of error variance

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	3.159251	2.450000	2.450000
Pre	24	3.604765	2.831597	2.812500

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.3855	1	46	0.5377
Brown-Forsythe	0.3616	1	46	0.5505
Levene	0.4188	1	46	0.5208
Bartlett	0.3906	1	?	0.5320

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
13.6952	1	45.222	0.0006
t-Test			
3.7007			

Means Comparisons

Dif=Mean[i]-Mean[j]	Post	Pre
Post	0.00000	3.62083
Pre	-3.62083	0.00000

Alpha= 0.05

Comparisons for each pair using Student's t

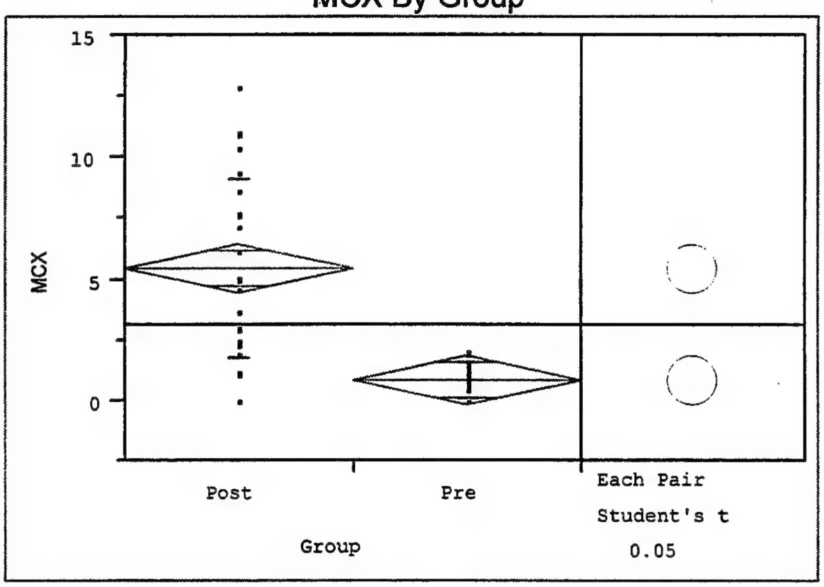
t

2.01289

Abs(Dif)-LSD	Post	Pre
Post	-1.96945	1.65139
Pre	1.65139	-1.96945

Positive values show pairs of means that are significantly different.

MCX By Group



Oneway Anova

Summary of Fit

RSquare	0.442028
RSquare Adj	0.429898
Root Mean Square Error	2.663586
Mean of Response	3.141667
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	258.54083	258.541	36.4414
Error	46	326.35583	7.095	Prob>F
C Total	47	584.89667	12.445	<.0001

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	5.46250	0.54370
Pre	24	0.82083	0.54370

Std Error uses a pooled estimate of error variance

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Post	24	832.5	34.6875	5.056
Pre	24	343.5	14.3125	-5.056

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
343.5	-5.05623	<.0001

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
25.6704	1	<.0001

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	3.691213	3.147917	3.079167
Pre	24	0.751219	0.662500	0.662500

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	20.2230	1	46	<.0001
Brown-Forsythe	32.5785	1	46	<.0001
Levene	43.7179	1	46	<.0001
Bartlett	42.2952	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
36.4414	1	24.902	<.0001
t-Test			
6.0367			

Means Comparisons

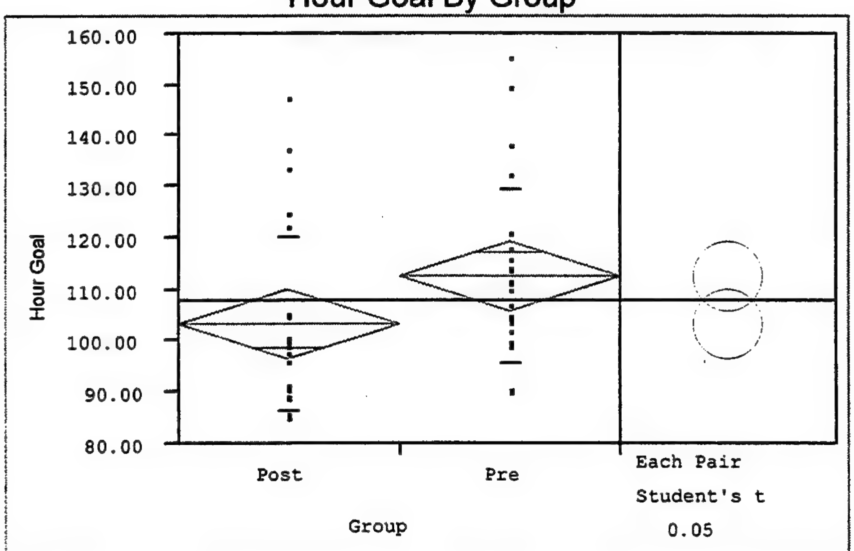
Dif=Mean[i]-Mean[j]	Post	Pre
Post	0.00000	4.64167
Pre	-4.64167	0.00000
Alpha=		0.05

Comparisons for each pair using Student's t

	t	
	2.01289	
Abs(Dif)-LSD	Post	Pre
Post	-1.54773	3.09393
Pre	3.09393	-1.54773

Positive values show pairs of means that are significantly different.

Hour Goal By Group



Oneway Anova

Summary of Fit

RSquare	0.070149
RSquare Adj	0.049935
Root Mean Square Error	17.00574
Mean of Response	107.9077
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1003.597	1003.60	3.4703
Error	46	13302.974	289.20	Prob>F
C Total	47	14306.570	304.40	0.0689

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	103.335	3.4713
Pre	24	112.480	3.4713

Std Error uses a pooled estimate of error variance

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Post	24	470	19.5833	-2.423
Pre	24	706	29.4167	2.423

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
706	2.42281	0.0154

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
5.9201	1	0.0150

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	17.05160	12.74872	11.43395
Pre	24	16.95975	12.24626	11.89827

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	0.0005	1	46	0.9825
Brown-Forsythe	0.0160	1	46	0.9000
Levene	0.0240	1	46	0.8775
Bartlett	0.0007	1	?	0.9796

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
3.4703	1	45.999	0.0689
t-Test			
1.8629			

Means Comparisons

Dif=Mean[i]-Mean[j]	Pre	Post
Pre	0.00000	9.14511
Post	-9.14511	0.00000
Alpha=		0.05

Comparisons for each pair using Student's t

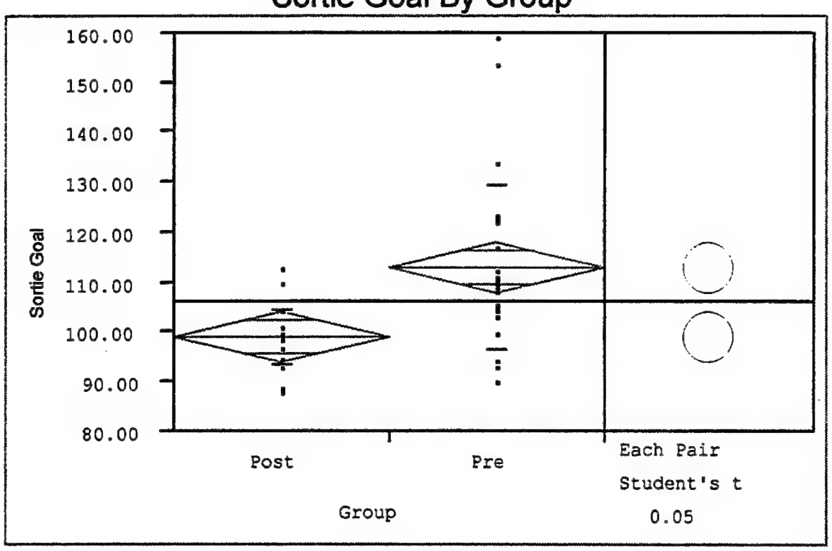
t

2.01289

Abs(Dif)-LSD	Pre	Post
Pre	-9.88154	-0.73643
Post	-0.73643	-9.88154

Positive values show pairs of means that are significantly different.

Sortie Goal By Group



Oneway Anova

Summary of Fit

RSquare	0.248857
RSquare Adj	0.232528
Root Mean Square Error	12.54826
Mean of Response	106.1162
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2399.6721	2399.67	15.2400
Error	46	7243.1079	157.46	Prob>F
C Total	47	9642.7800	205.17	0.0003

Means for Oneway Anova

Level	Number	Mean	Std Error
Post	24	99.046	2.5614
Pre	24	113.187	2.5614

Std Error uses a pooled estimate of error variance

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Score Mean	(Mean-Mean0)/Std0
Post	24	395	16.4583	-3.975
Pre	24	781	32.5417	3.975

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
781	3.97544	<.0001

1-way Test, Chi-Square Approximation

ChiSquare	DF	Prob>ChiSq
15.8863	1	<.0001

Tests that the Variances are Equal

Level	Count	Std Dev	MeanAbsDif to Mean	MeanAbsDif to Median
Post	24	5.82768	3.67129	3.66992
Pre	24	16.76174	11.81826	11.07524

Test	F Ratio	DF Num	DF Den	Prob>F
O'Brien[.5]	4.5522	1	46	0.0382
Brown-Forsythe	7.1012	1	46	0.0106
Levene	10.2699	1	46	0.0025
Bartlett	21.4953	1	?	<.0001

Welch Anova testing Means Equal, allowing Std's Not Equal

F Ratio	DF Num	DF Den	Prob>F
15.2400	1	28.48	0.0005
t-Test			
3.9038			

Means Comparisons

Dif=Mean[i]-Mean[j]	Pre	Post
Pre	0.0000	14.1412
Post	-14.1412	0.0000

Alpha= 0.05

Comparisons for each pair using Student's t

	t	
	2.01289	
Abs(Dif)-LSD	Pre	Post
Pre	-7.29143	6.84974
Post	6.84974	-7.29143

Positive values show pairs of means that are significantly different.

APPENDIX I: Stepwise and Standard Least Squares Regression Results

1. Stepwise results for Pre-Reorg MC Rate

Response: MC
Stepwise Regression Control

Prob to Enter	0.050
Prob to Leave	0.050

Current Estimates

SSE	DFE	MSE	RSquare	RSquare Adj	Cp	AIC
1.1936511	11	0.108514	0.9937	0.9873	22.39753	-44.045

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
X	X	Intercept	15.7902533	1	0	0.000	1.0000
_	_	POSS	?	1	0.021322	0.182	0.6788
_	X	NMCM	-0.7608846	1	24.83693	228.883	0.0000
_	X	NMCS	-0.7682597	1	30.40818	280.224	0.0000
_	X	ASE	0.26545135	1	1.385246	12.766	0.0044
_	X	CLT	0.32227598	1	1.189343	10.960	0.0069
_	_	GA	?	1	0.011655	0.099	0.7600
_	_	AA	?	1	0.249446	2.642	0.1351
_	_	MCX	?	1	0.010478	0.089	0.7721
_	X	CANN	0.12431037	1	2.932223	27.022	0.0003
_	X	BRK	0.11346589	1	0.751384	6.924	0.0233
_	X	FIX	0.02329919	1	0.834326	7.689	0.0181
_	_	REP	?	1	0.002357	0.020	0.8909
_	_	REC	?	1	0.062314	0.551	0.4751
_	_	DD	?	1	0.003421	0.029	0.8688
_	_	PHUT	?	1	0.005008	0.042	0.8415
_	_	PSUT	?	1	0.021392	0.182	0.6783
_	_	AHUT	?	1	0.000532	0.004	0.9481
_	X	ASUT	1.12330175	1	3.145647	28.988	0.0002
_	X	MEFF	0.3035436	1	2.321408	21.393	0.0007
_	X	MFH	0.05162848	1	0.553123	5.097	0.0453
_	X	Lag1 MC	0.10015649	1	0.720556	6.640	0.0257

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p
1	MCX	Removed	0.8623	0.002693	0.9997	20.048	21
2	DD	Removed	0.5267	0.016881	0.9996	18.351	20
3	REC	Removed	0.2565	0.049105	0.9993	17.231	19
4	PHUT	Removed	0.1323	0.1107	0.9988	17.216	18
5	GA	Removed	0.1386	0.145825	0.9980	17.83	17
6	PSUT	Removed	0.1545	0.168486	0.9971	18.85	16
7	REP	Removed	0.2952	0.100478	0.9965	18.651	15
8	AHUT	Removed	0.1290	0.232792	0.9953	20.824	14
9	POSS	Removed	0.4490	0.06146	0.9950	19.926	13
10	AA	Removed	0.1351	0.249446	0.9937	22.398	12

2. Standard Least Squares Results for Pre-Reorg MC Rate

Response: MC

Summary of Fit

RSquare	0.99366
RSquare Adj	0.98732
Root Mean Square Error	0.329414
Mean of Response	85.91304
Observations (or Sum Wgts)	23

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	15.790253	14.86952	1.06	0.3110
NMCM	-0.760885	0.050294	-15.13	<.0001
NMCS	-0.76826	0.045894	-16.74	<.0001
ASE	0.2654514	0.074296	3.57	0.0044
CLT	0.322276	0.097346	3.31	0.0069
CANN	0.1243104	0.023914	5.20	0.0003
BRK	0.1134659	0.04312	2.63	0.0233
FIX	0.0232992	0.008403	2.77	0.0181
ASUT	1.1233018	0.208633	5.38	0.0002
MEFF	0.3035436	0.065628	4.63	0.0007
MFH	0.0516285	0.022868	2.26	0.0453
Lag1 MC	0.1001565	0.038868	2.58	0.0257

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
NMCM	1	1	24.836934	228.8829	<.0001
NMCS	1	1	30.408181	280.2243	<.0001
ASE	1	1	1.385246	12.7656	0.0044
CLT	1	1	1.189343	10.9603	0.0069
CANN	1	1	2.932223	27.0217	0.0003
BRK	1	1	0.751384	6.9243	0.0233
FIX	1	1	0.834326	7.6887	0.0181
ASUT	1	1	3.145647	28.9885	0.0002
MEFF	1	1	2.321408	21.3928	0.0007
MFH	1	1	0.553123	5.0973	0.0453
Lag1 MC	1	1	0.720556	6.6402	0.0257

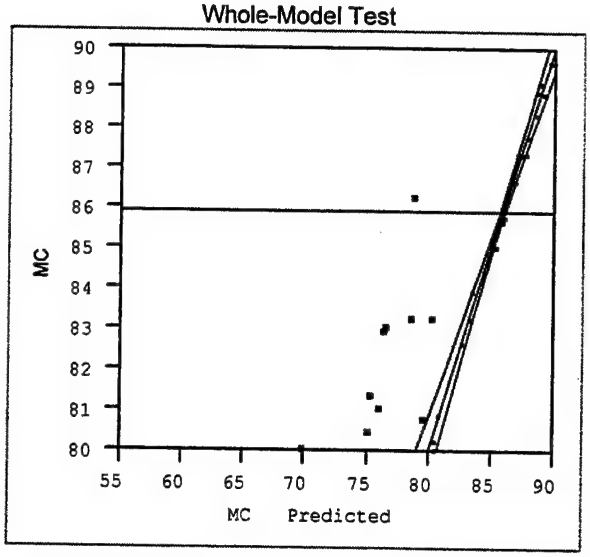
Durbin-Watson

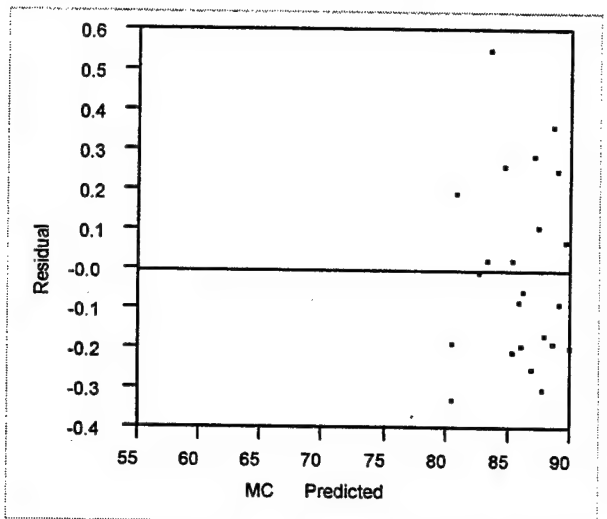
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.1103486	23	-0.0697	0.3893

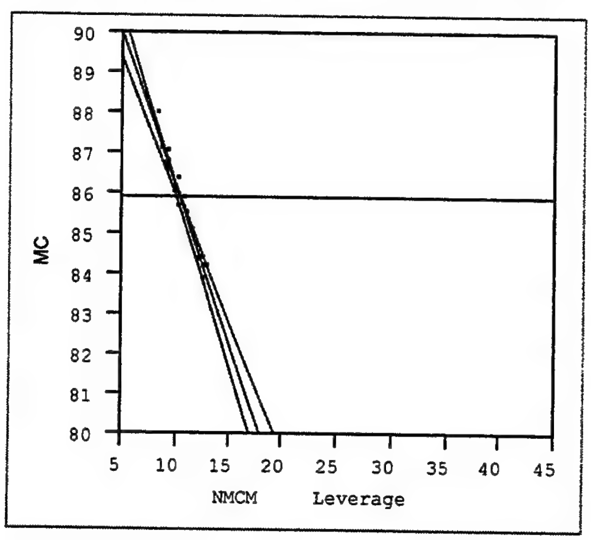
Analysis of Variance

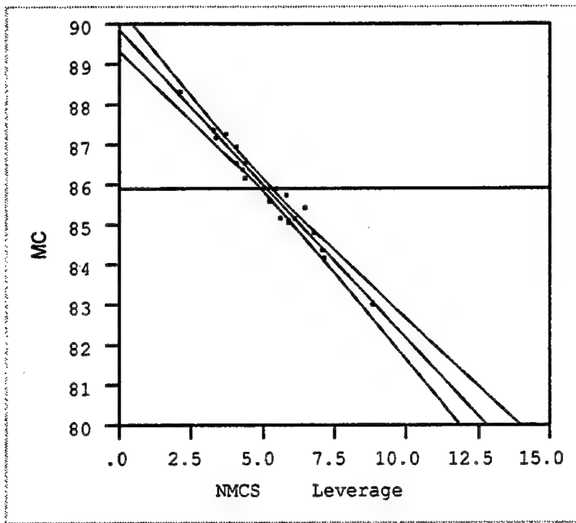
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	187.07244	17.0066	156.7229
Error	11	1.19365	0.1085	Prob>F
C Total	22	188.26609		<.0001

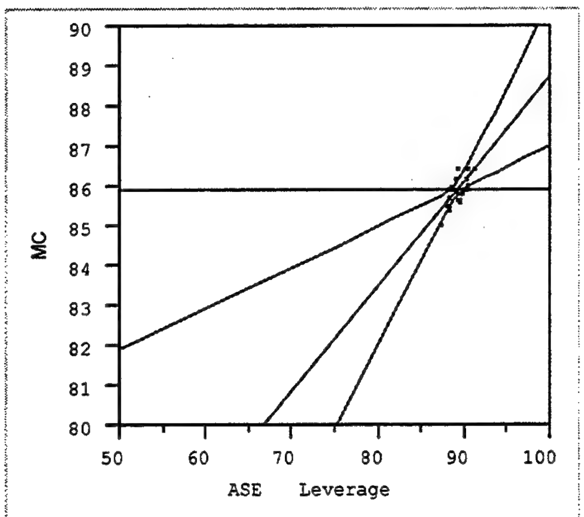
Whole-Model Test

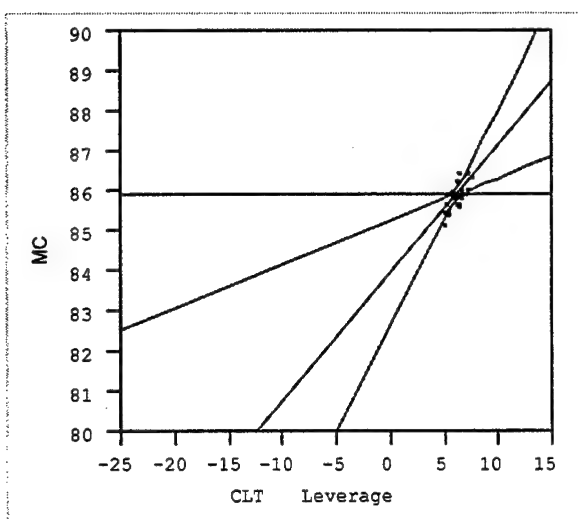


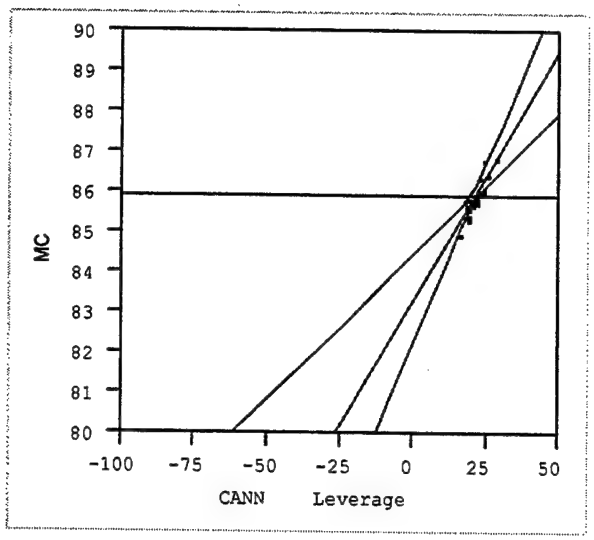





MC
NMCS Leverage


MC
ASE Leverage


MC
CLT Leverage


90
89
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87
86
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84
83
82
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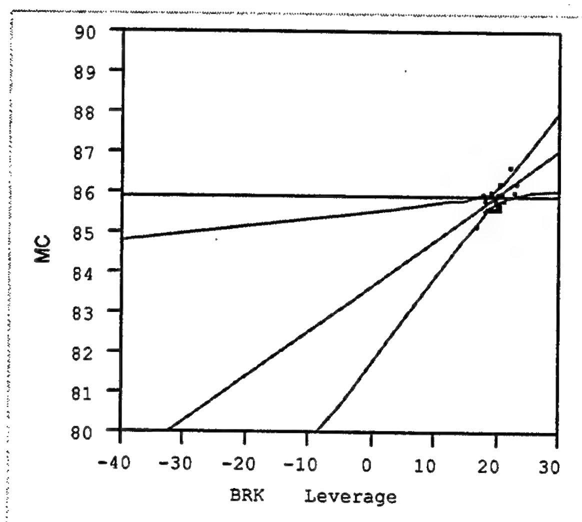
80
MC
-100
-75
-50
-25
0
25
50
CANN Leverage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MC
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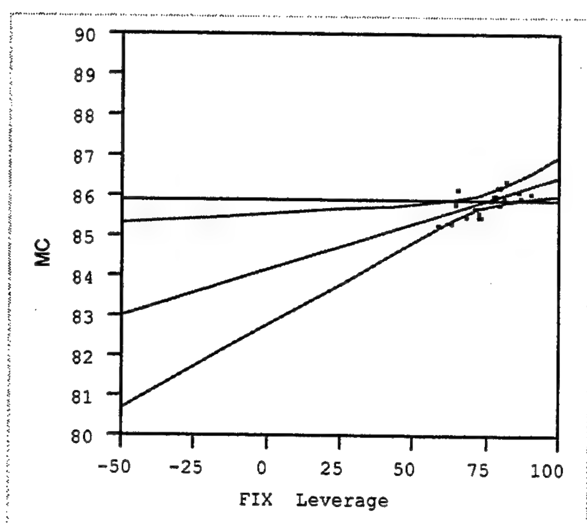
30
BRK Leverage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MC
-50
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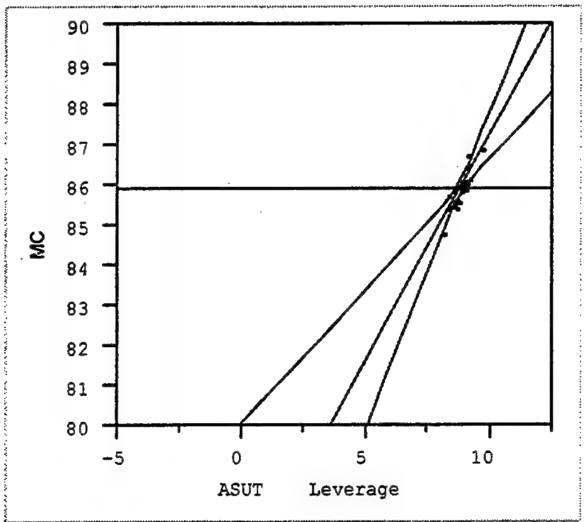
FIX Leverage



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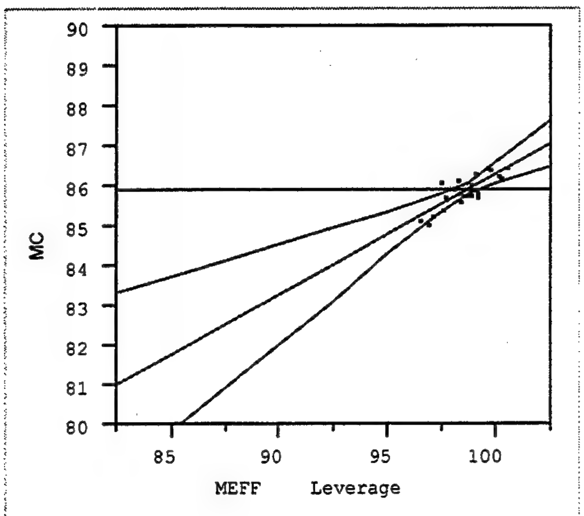
ASUT Leverage



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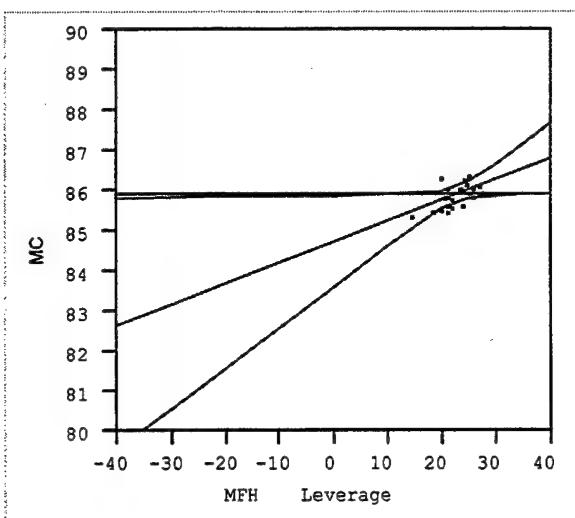
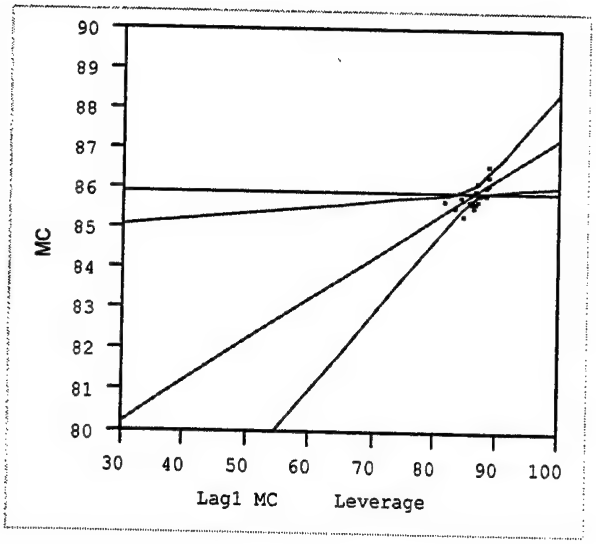
MC
85
90
95
100
MEFF Leverage

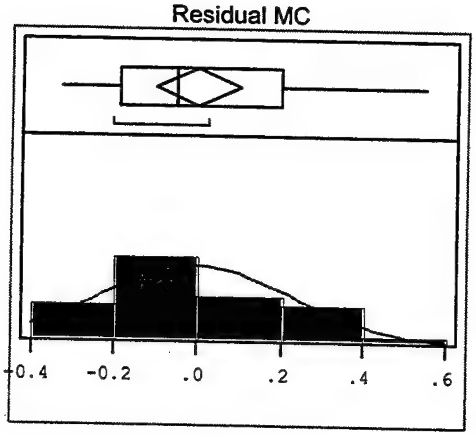


90
89
88
87
86
85
84
83
82
81
80
MC
-40
-30
-20
-10
0
10
20
30
40
MFH Leverage



3. Residual Analysis of the Errors for Pre-Reorg MC Model

Residual MC



Moments

Mean	-0.00000
Std Dev	0.23293
Std Error Mean	0.04857
Upper 95% Mean	0.10073
Lower 95% Mean	-0.10073
N	23.00000
Sum Weights	23.00000

Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.942153	0.2017

4. Stepwise Results for Pre-Reorg MFH Rate

Response: MFH
Stepwise Regression Control

Prob to Enter	0.050
Prob to Leave	0.050

Current Estimates

SSE	DFE	MSE	RSquare	RSquare Adj	Cp	AIC
97.460568	11	8.860052	0.8215	0.6429	7.897673	57.21093

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
X	X	Intercept	-22.068946	1	0	0.000	1.0000
_	_	POSS	?	1	4.252244	0.456	0.5147
_	X	MC	6.55648531	1	99.24524	11.201	0.0065
_	X	NMCM	5.2138912	1	101.2883	11.432	0.0061
_	X	NMCS	4.62507511	1	86.93304	9.812	0.0095
_	X	ASE	-2.2994444	1	212.8562	24.024	0.0005
_	X	CLT	-2.9111904	1	194.3657	21.937	0.0007
_	_	GA	?	1	3.412976	0.363	0.5603
_	_	AA	?	1	1.767372	0.185	0.6765
_	_	MCX	?	1	4.254446	0.456	0.5146
_	X	CANN	-0.9659358	1	164.0545	18.516	0.0012
_	X	BRK	-0.9265046	1	105.8958	11.952	0.0054
_	X	FIX	-0.2418586	1	112.5309	12.701	0.0044
_	_	REP	?	1	7.469939	0.830	0.3837
_	_	REC	?	1	2.845996	0.301	0.5954
_	_	DD	?	1	2.099263	0.220	0.6490
_	_	PHUT	?	1	2.482896	0.261	0.6202
_	_	PSUT	?	1	3.975477	0.425	0.5290
_	_	AHUT	?	1	3.231742	0.343	0.5711
_	X	ASUT	-8.3863352	1	211.2338	23.841	0.0005
_	X	MEFF	-2.5746328	1	109.1573	12.320	0.0049
_	X	Lag1 MFH	0.49472023	1	53.85103	6.078	0.0314

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p
1	GA	Removed	0.9562	0.066984	0.9740	20.005	21
2	PHUT	Removed	0.6510	1.969084	0.9704	18.144	20
3	MCX	Removed	0.4353	4.34679	0.9624	16.452	19
4	REC	Removed	0.2710	8.350734	0.9471	15.043	18
5	DD	Removed	0.1163	20.77297	0.9091	14.513	17
6	AHUT	Removed	0.3686	7.815891	0.8948	13.066	16
7	AA	Removed	0.2020	16.26531	0.8650	12.217	15
8	PSUT	Removed	0.3651	8.494255	0.8494	10.818	14
9	POSS	Removed	0.3802	7.779126	0.8352	9.369	13
10	REP	Removed	0.3837	7.469939	0.8215	7.8977	12

5. Standard Least Squares Results for Pre-Reorg MFH Rate

Response: MFH
Summary of Fit

RSquare	0.821466
RSquare Adj	0.642933
Root Mean Square Error	2.976584
Mean of Response	22.73913
Observations (or Sum Wgts)	23

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-22.06895	143.3563	-0.15	0.8804
MC	6.5564853	1.959	3.35	0.0065
NMCM	5.2138912	1.542057	3.38	0.0061
NMCS	4.6250751	1.476537	3.13	0.0095
ASE	-2.299444	0.469135	-4.90	0.0005
CLT	-2.91119	0.621554	-4.68	0.0007
CANN	-0.965936	0.224477	-4.30	0.0012
BRK	-0.926505	0.267995	-3.46	0.0054
FIX	-0.241859	0.067865	-3.56	0.0044
ASUT	-8.386335	1.717547	-4.88	0.0005
MEFF	-2.574633	0.733512	-3.51	0.0049
Lag1 MFH	0.4947202	0.200669	2.47	0.0314

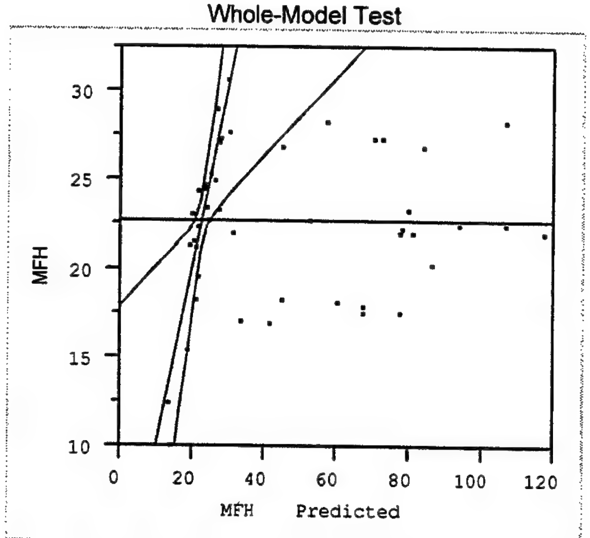
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
MC	1	1	99.24524	11.2014	0.0065
NMCM	1	1	101.28831	11.4320	0.0061
NMCS	1	1	86.93304	9.8118	0.0095
ASE	1	1	212.85624	24.0243	0.0005
CLT	1	1	194.36566	21.9373	0.0007
CANN	1	1	164.05450	18.5162	0.0012
BRK	1	1	105.89584	11.9521	0.0054
FIX	1	1	112.53089	12.7009	0.0044
ASUT	1	1	211.23378	23.8411	0.0005
MEFF	1	1	109.15727	12.3202	0.0049
Lag1 MFH	1	1	53.85103	6.0780	0.0314

Durbin-Watson

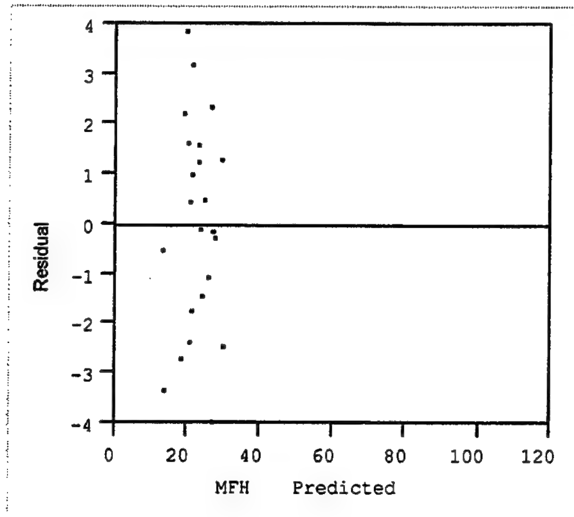
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.5335274	23	-0.2966	0.8298

Whole-Model Test



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	11	448.43422	40.7667	4.6012
Error	11	97.46057	8.8601	Prob>F
C Total	22	545.89478		0.0089


Residual
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0
-1
-2
-3
-4
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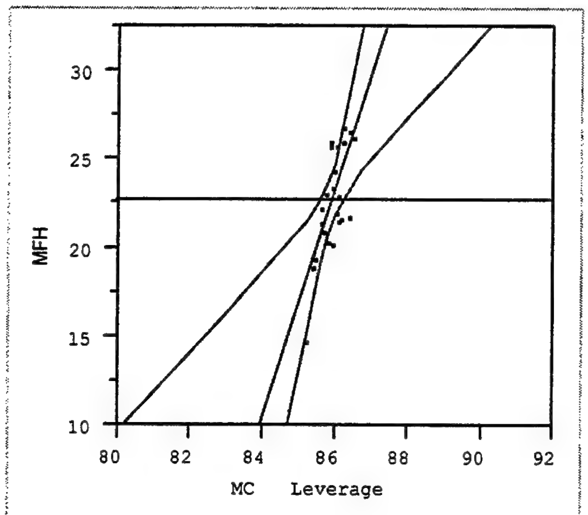
60
80
100
120
MFH Predicted


MFH
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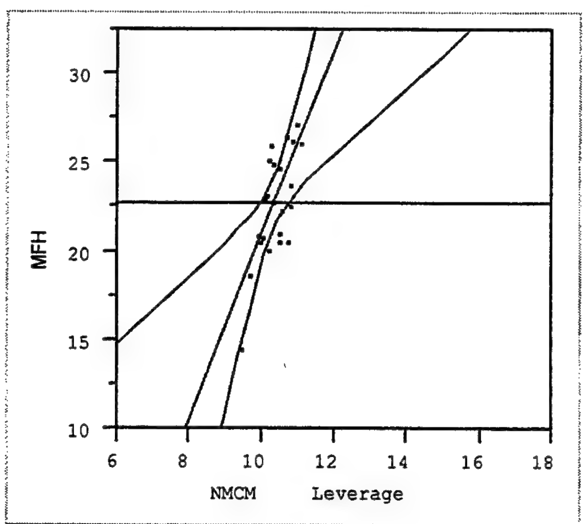
92
MC Leverage


MFH
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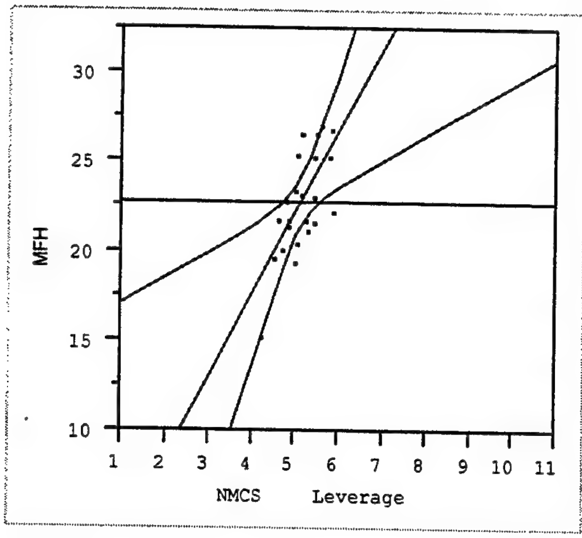
18
NMCM Leverage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MFH
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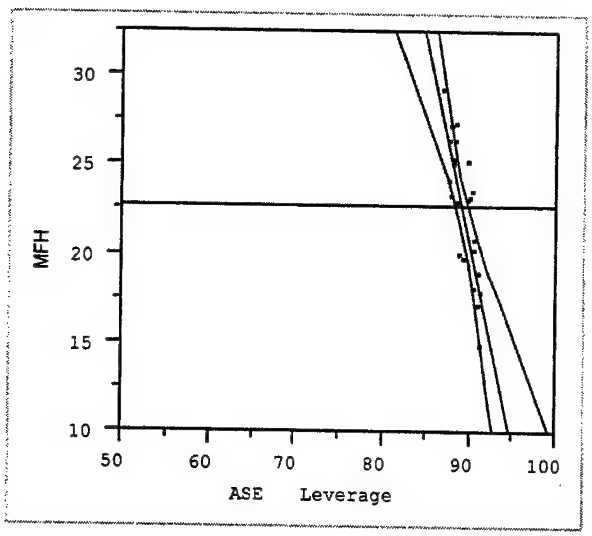
11
NMCS Leverage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MFH
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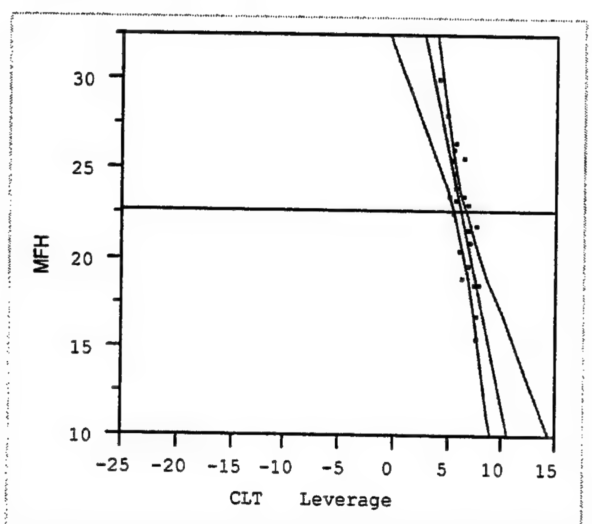
90
100
ASE Leverage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MFH
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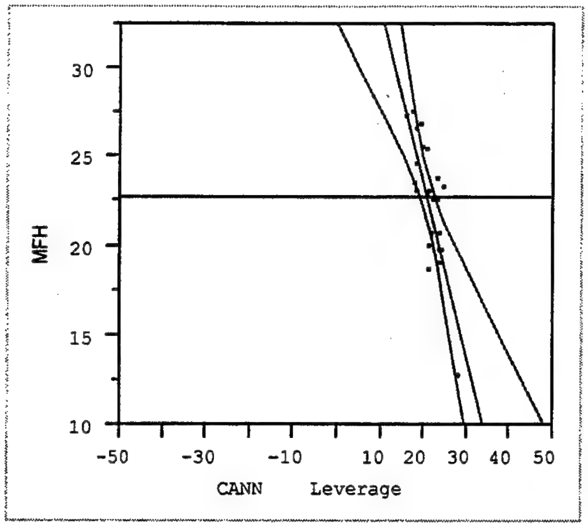
-10
-5
0
5
10
15
CLT Leverage


MFH
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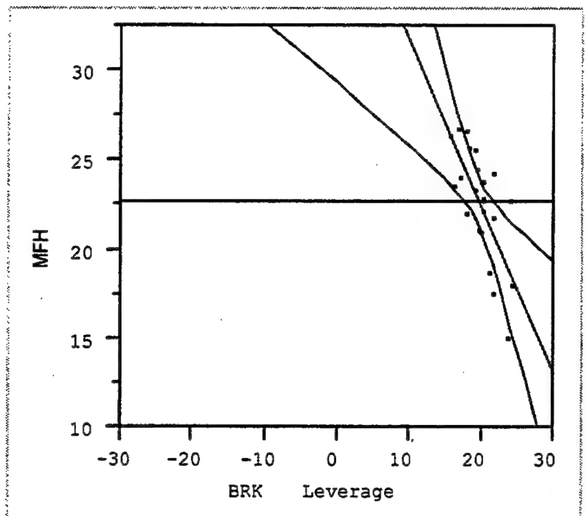
50
CANN Leverage


MFH
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0
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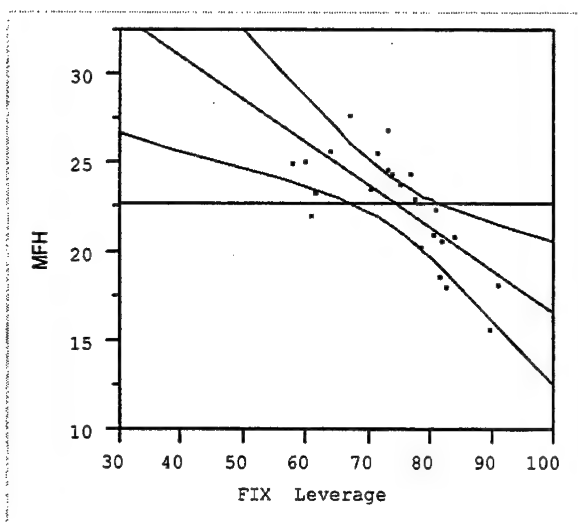
30
BRK Leverage


MFH
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25
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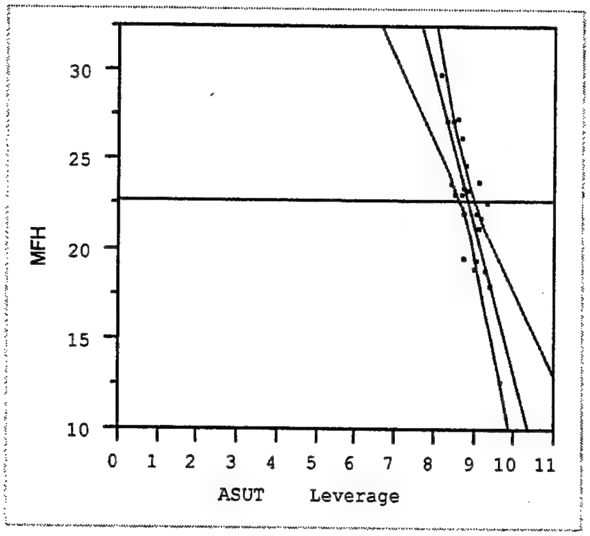
15
10
30
40
50
60
70
80
90
100
FIX Leverage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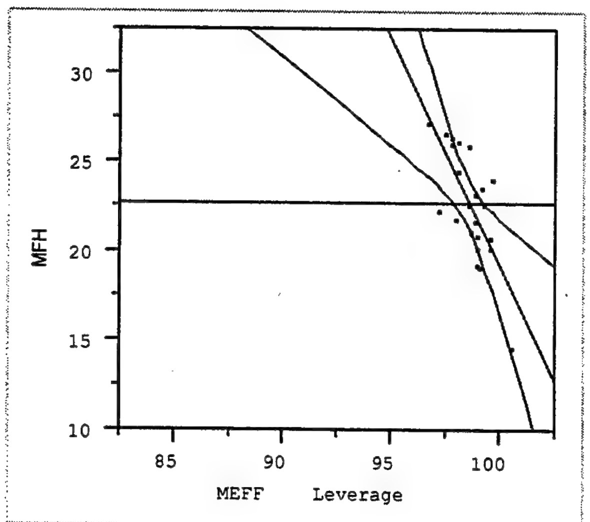
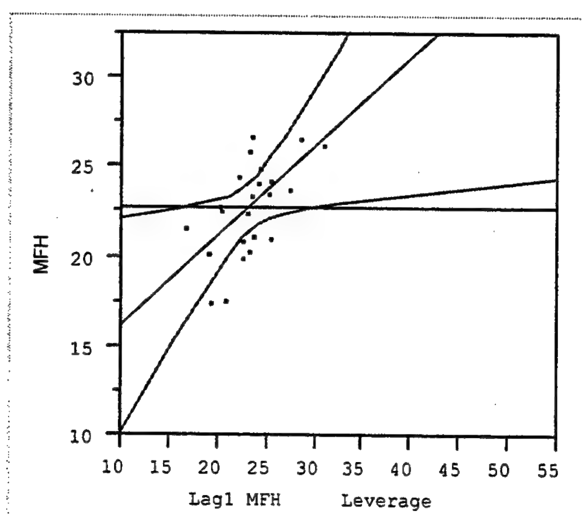
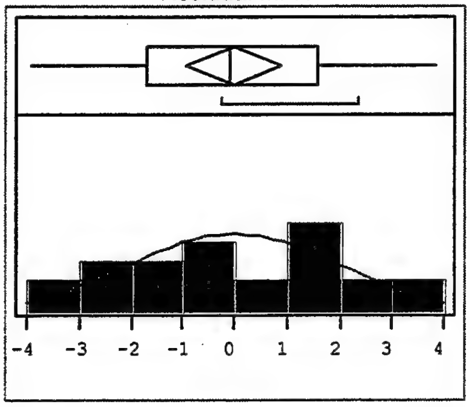
MFH
0 1 2 3 4 5 6 7 8 9 10 11
ASUT Leverage


30
25
20
15
10
MFH
85 90 95 100
MEFF Leverage


30
25
20
15
10
MFH
10 15 20 25 30 35 40 45 50 55
Lag1 MFH Leverage

6. Residual Analysis of the Errors for Pre-Reorg MFH Model

Residual MFH



Moments

Mean	-0.00000
Std Dev	2.10476
Std Error Mean	0.43887
Upper 95% Mean	0.91016
Lower 95% Mean	-0.91016
N	23.00000
Sum Weights	23.00000

Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.980965	0.9101

7. Stepwise results for Post-Reorg MC Rate

Response: MC
Stepwise Regression Control

Prob to Enter	0.050
Prob to Leave	0.050

Current Estimates

SSE	DFE	MSE	RSquare	RSquare Adj	Cp	AIC
1.8596833	9	0.206631	0.9976	0.9939	14.02582	-31.3835

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
X	X	Intercept	112.567481	1	0	0.000	1.0000
_	X	POSS	-0.729614	1	1.356598	6.565	0.0306
_	X	NMCM	-0.5109694	1	8.230094	39.830	0.0001
_	X	NMCS	-1.0839161	1	37.3099	180.563	0.0000
_	X	ASE	-0.1077121	1	2.445327	11.834	0.0074
_	_	CLT	?	1	0.563092	3.474	0.0993
_	X	GA	-0.8887464	1	9.094807	44.015	0.0001
_	_	AA	?	1	0.096877	0.440	0.5259
_	X	MCX	-0.1548768	1	1.84545	8.931	0.0152
_	X	CANN	0.06817248	1	3.50376	16.957	0.0026

–	–	BRK	?	1	0.000144	0.001	0.9807
–	X	FIX	0.12295921	1	6.184948	29.932	0.0004
–	–	REP	?	1	0.300485	1.542	0.2495
–	–	REC	?	1	0.205151	0.992	0.3484
–	X	DD	0.11471361	1	3.048676	14.754	0.0040
–	X	PHUT	-0.0912552	1	4.154699	20.107	0.0015
–	–	PSUT	?	1	0.131005	0.606	0.4586
–	X	AHUT	-0.1783908	1	4.202294	20.337	0.0015
–	X	ASUT	1.40757423	1	2.479897	12.002	0.0071
–	X	MEFF	-0.1275482	1	2.149886	10.404	0.0104
–	–	MFH	?	1	0.000125	0.001	0.9821
–	X	Lag1 MC	0.11120753	1	2.243909	10.859	0.0093

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p
1	BRK	Removed	0.7916	0.021037	0.9994	20.091	21
2	PSUT	Removed	0.7821	0.014765	0.9994	18.155	20
3	MFH	Removed	0.5625	0.049643	0.9993	16.369	19
4	AA	Removed	0.6097	0.032513	0.9992	14.509	18
5	REP	Removed	0.2360	0.167983	0.9990	13.234	17
6	REC	Removed	0.0583	0.547225	0.9983	13.596	16
7	CLT	Removed	0.0993	0.563092	0.9976	14.026	15

8. Standard Least Squares Results for Post-Reorg MC Rate

Response: MC

Summary of Fit

RSquare	0.997599
RSquare Adj	0.993863
Root Mean Square Error	0.454567
Mean of Response	77.47917
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	112.56748	6.879227	16.36	<.0001
POSS	-0.729614	0.284751	-2.56	0.0306
NMCM	-0.510969	0.080964	-6.31	0.0001
NMCS	-1.083916	0.080664	-13.44	<.0001
ASE	-0.107712	0.031311	-3.44	0.0074
GA	-0.888746	0.133961	-6.63	<.0001
MCX	-0.154877	0.051824	-2.99	0.0152
CANN	0.0681725	0.016555	4.12	0.0026
FIX	0.1229592	0.022475	5.47	0.0004
DD	0.1147136	0.029865	3.84	0.0040
PHUT	-0.091255	0.020351	-4.48	0.0015
AHUT	-0.178391	0.039557	-4.51	0.0015
ASUT	1.4075742	0.406306	3.46	0.0071
MEFF	-0.127548	0.039543	-3.23	0.0104
Lag1 MC	0.1112075	0.033747	3.30	0.0093

Effect Test

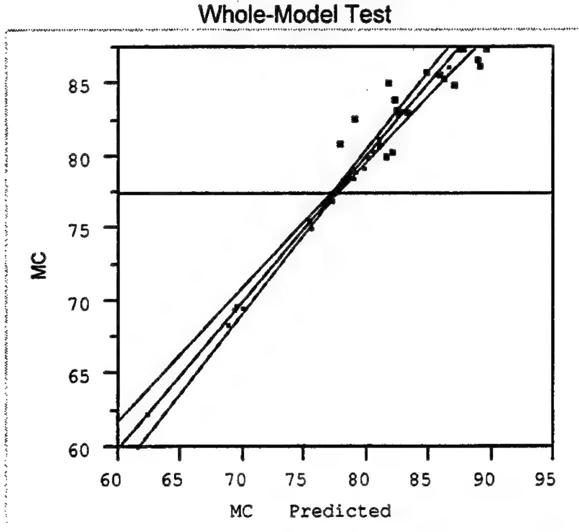
Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
POSS	1	1	1.356598	6.5653	0.0306
NMCM	1	1	8.230094	39.8298	0.0001
NMCS	1	1	37.309899	180.5625	<.0001

ASE	1	1	2.445327	11.8342	0.0074
GA	1	1	9.094807	44.0146	<.0001
MCX	1	1	1.845450	8.9311	0.0152
CANN	1	1	3.503760	16.9566	0.0026
FIX	1	1	6.184948	29.9323	0.0004
DD	1	1	3.048676	14.7542	0.0040
PHUT	1	1	4.154699	20.1068	0.0015
AHUT	1	1	4.202294	20.3371	0.0015
ASUT	1	1	2.479897	12.0015	0.0071
MEFF	1	1	2.149886	10.4044	0.0104
Lag1 MC	1	1	2.243909	10.8595	0.0093

Durbin-Watson

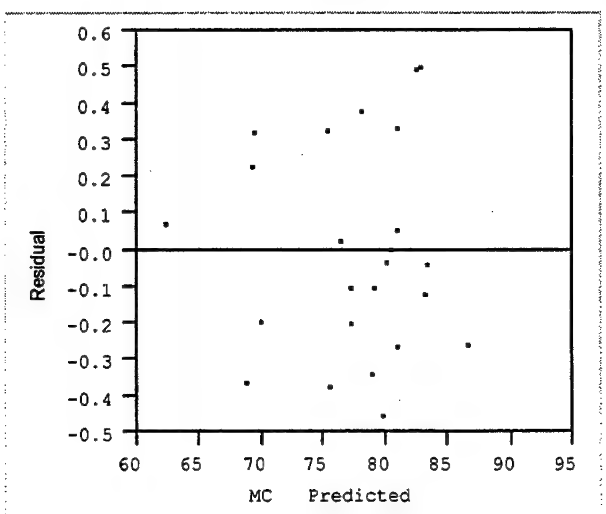
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.9627925	24	-0.4963	0.9563

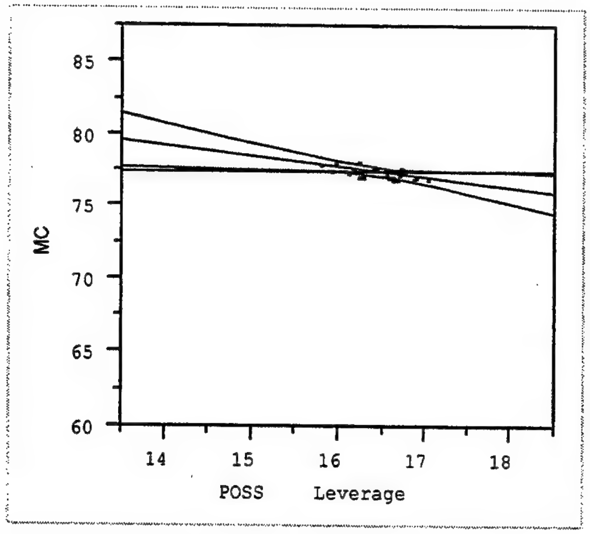
Whole-Model Test



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	14	772.59990	55.1857	267.0731
Error	9	1.85968	0.2066	Prob>F
C Total	23	774.45958		<.0001

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MC
14
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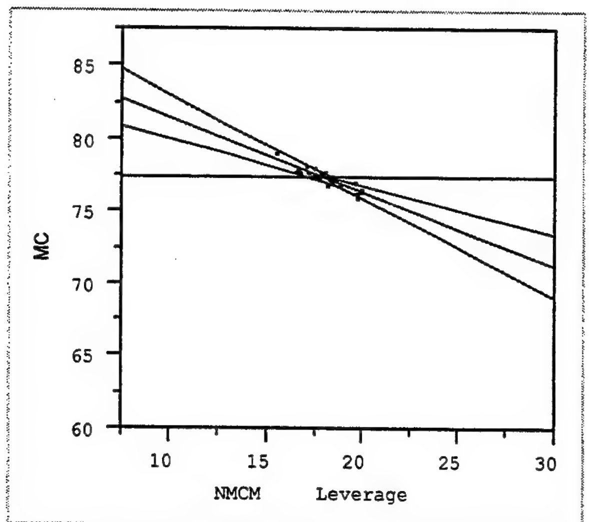
18
POSS Leverage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MC
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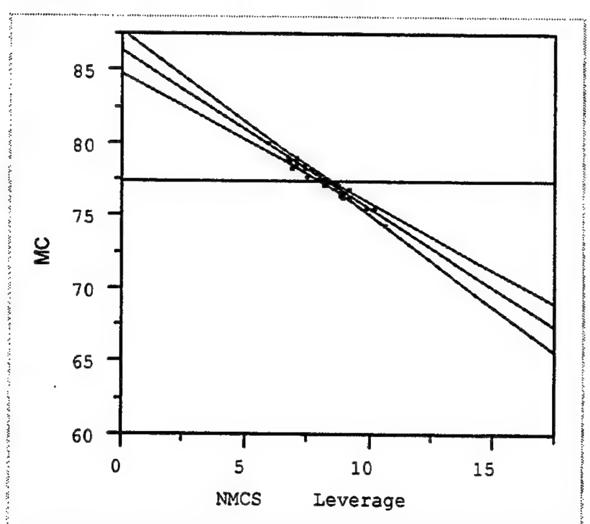
30
NMCM Leverage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MC
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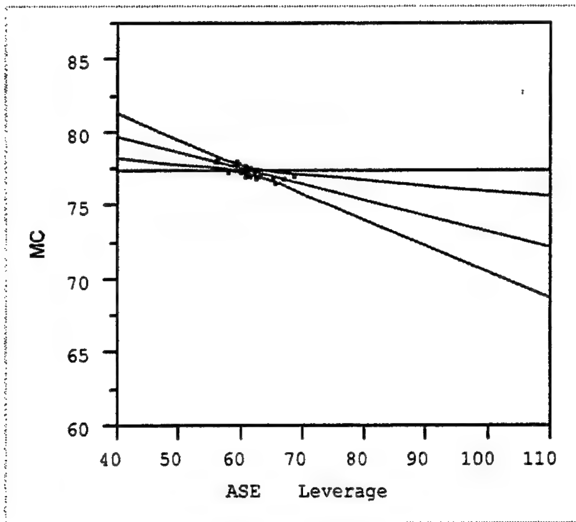
10
15
NMCS Leverage


MC
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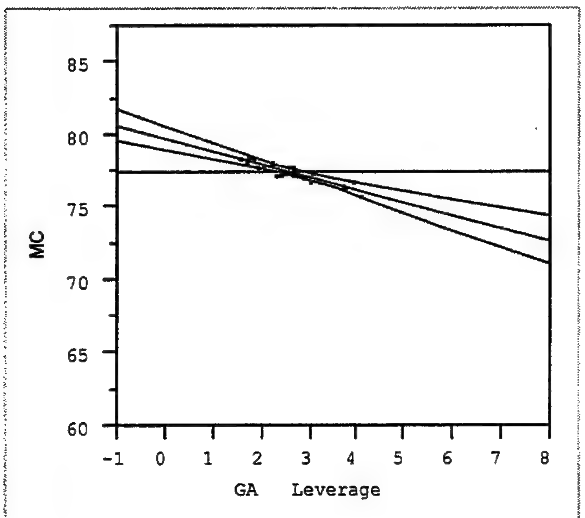
70
65
60
40 50 60 70 80 90 100 110
ASE Leverage


MC
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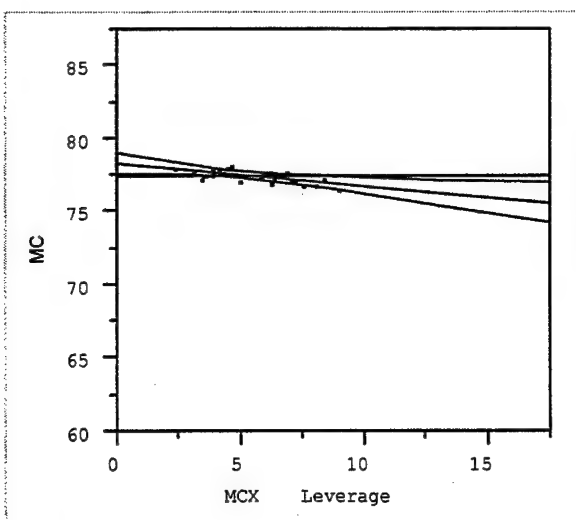
GA Leverage


MC
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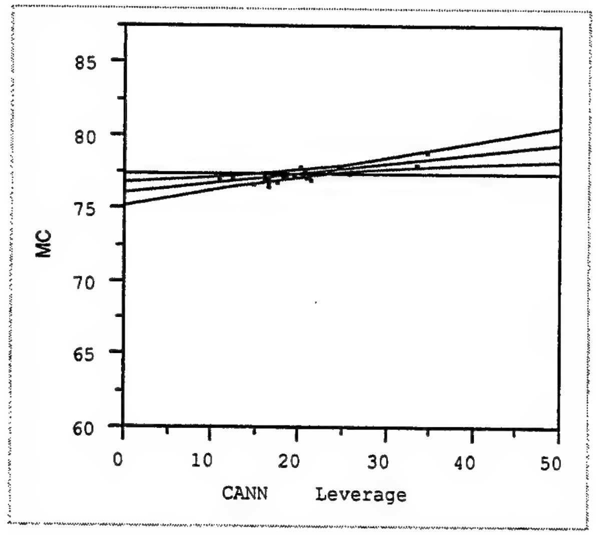
MCX Leverage


MC
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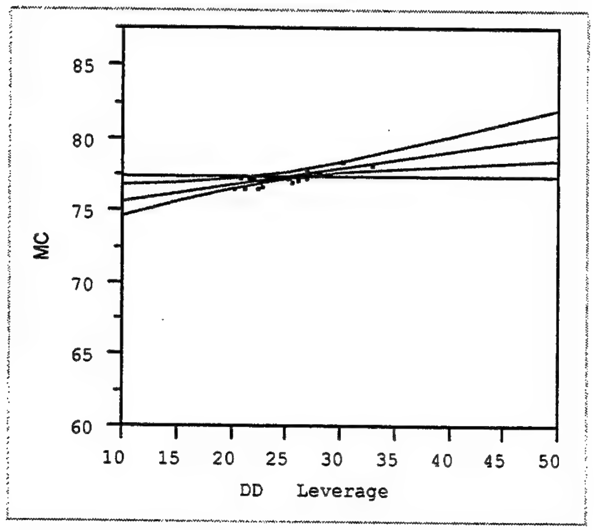
CANN Leverage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45
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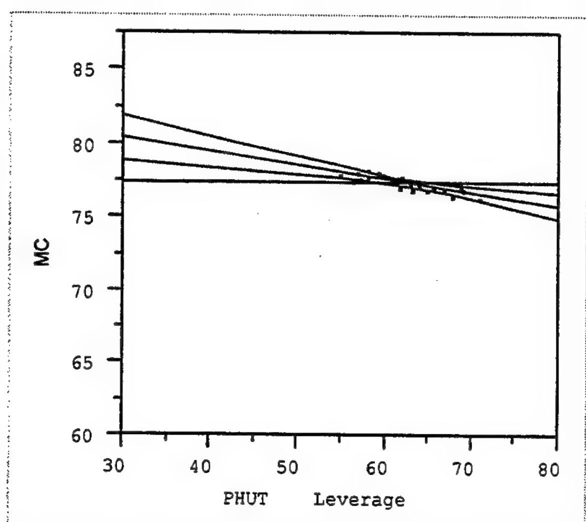
DD Leverage


MC
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75
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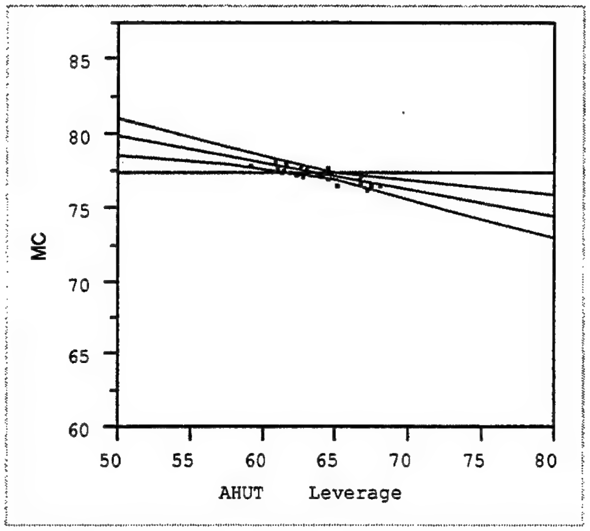
65
60
30
40
50
60
70
80
PHUT Leverage


MC
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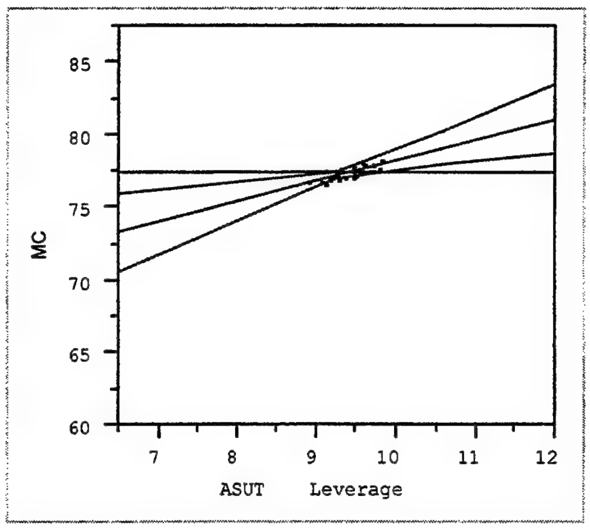
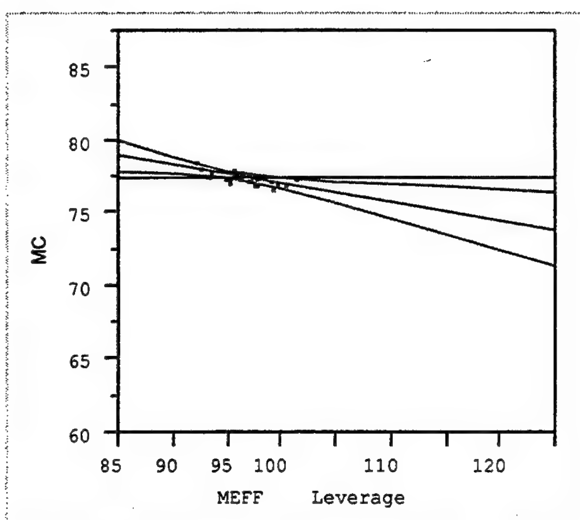
80
75
70
65
60
50
55
60
65
70
75
80
AHUT Leverage


MC
85
80
75
70
65
60
7
8
9
10
11
12
ASUT Leverage


MC
85
80
75
70
65
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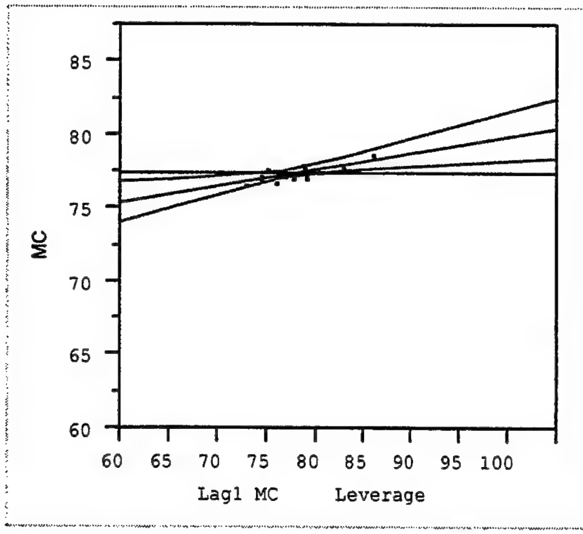
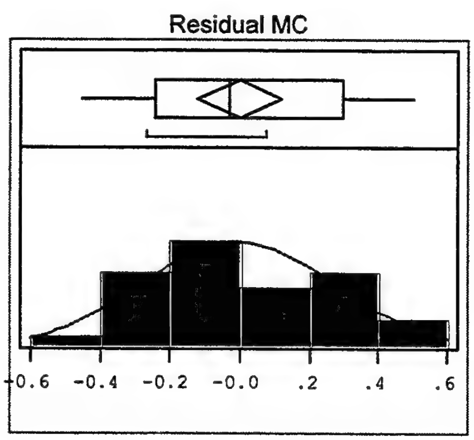
85
90
95
100
110
120
MEFF Leverage



9. Residual Analysis of the Errors for Post-Reorg MC Model



Moments

Mean	-0.00000
Std Dev	0.28435
Std Error Mean	0.05804
Upper 95% Mean	0.12007
Lower 95% Mean	-0.12007
N	24.00000
Sum Weights	24.00000

Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.947924	0.2509

10. Stepwise results for Post-Reorg MFH Rate

Response: MFH
Stepwise Regression Control
Prob to Enter 0.100
Prob to Leave 0.100

Current Estimates

SSE	DFE	MSE	RSquare	RSquare Adj	Cp	AIC
217.99009	17	12.82295	0.5210	0.3519	-6.31115	66.9535

Lock	Entered	Parameter	Estimate	nDF	SS	"F Ratio"	"Prob>F"
X	X	Intercept	227.327076	1	0	0.000	1.0000
_	X	POSS	4.01433664	1	81.13012	6.327	0.0222
_	X	MC	-2.6930233	1	117.4398	9.159	0.0076
_	X	NMCM	-1.2402222	1	47.22562	3.683	0.0719
_	X	NMCS	-1.6151709	1	67.60971	5.273	0.0346
_	_	ASE	?	1	3.043196	0.227	0.6405
_	_	CLT	?	1	1.53319	0.113	0.7408
_	_	GA	?	1	2.457786	0.182	0.6750
_	X	AA	-2.3936966	1	92.70868	7.230	0.0155
_	_	MCX	?	1	5.555497	0.418	0.5269
_	_	CANN	?	1	2.593595	0.193	0.6666
_	X	BRK	-0.6194519	1	110.0645	8.583	0.0094
_	_	FIX	?	1	2.62714	0.195	0.6646
_	_	REP	?	1	0.245109	0.018	0.8949
_	_	REC	?	1	0.063739	0.005	0.9463
_	_	DD	?	1	2.627649	0.195	0.6645
_	_	PHUT	?	1	7.324444	0.556	0.4666
_	_	PSUT	?	1	3.402887	0.254	0.6213
_	_	AHUT	?	1	2.799162	0.208	0.6544
_	_	ASUT	?	1	0.90811	0.067	0.7992
_	_	MEFF	?	1	1.542595	0.114	0.7400
_	_	Lag1 MFH	?	1	2.600037	0.193	0.6662

Step History

Step	Parameter	Action	"Sig Prob"	Seq SS	RSquare	Cp	p
1	CLT	Removed	0.8395	3.124205	0.7334	20.053	21
2	FIX	Removed	0.8748	1.18863	0.7308	18.073	20
3	ASUT	Removed	0.8377	1.463661	0.7276	16.098	19
4	CANN	Removed	0.6642	5.266393	0.7160	14.187	18
5	REP	Removed	0.3233	24.93198	0.6612	12.609	17
6	DD	Removed	0.4690	12.90488	0.6329	10.827	16
7	MCX	Removed	0.7179	2.925113	0.6264	8.8766	15
8	Lag1 MFH	Removed	0.6259	4.811684	0.6159	6.9581	14
9	AHUT	Removed	0.6490	3.847251	0.6074	5.0232	13
10	PHUT	Removed	0.5271	6.927273	0.5922	3.1404	12
11	MEFF	Removed	0.4909	7.810587	0.5750	1.2726	11
12	REC	Removed	0.4102	10.77094	0.5513	-0.545	10
13	GA	Removed	0.5407	5.733495	0.5387	-2.448	9
14	ASE	Removed	0.5711	4.692551	0.5284	-4.369	8
15	PSUT	Removed	0.6213	3.402887	0.5210	-6.311	7

11. Standard Least Squares Results for Post-Reorg MFH Rate

Response: MFH
Summary of Fit

RSquare	0.520953
RSquare Adj	0.351878
Root Mean Square Error	3.580914
Mean of Response	22.77083
Observations (or Sum Wgts)	24

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	227.32708	78.68257	2.89	0.0102
BRK	-0.619452	0.211436	-2.93	0.0094
AA	-2.393697	0.890231	-2.69	0.0155
POSS	4.0143366	1.59594	2.52	0.0222
MC	-2.693023	0.88987	-3.03	0.0076
NMCM	-1.240222	0.646256	-1.92	0.0719
NMCS	-1.615171	0.703409	-2.30	0.0346

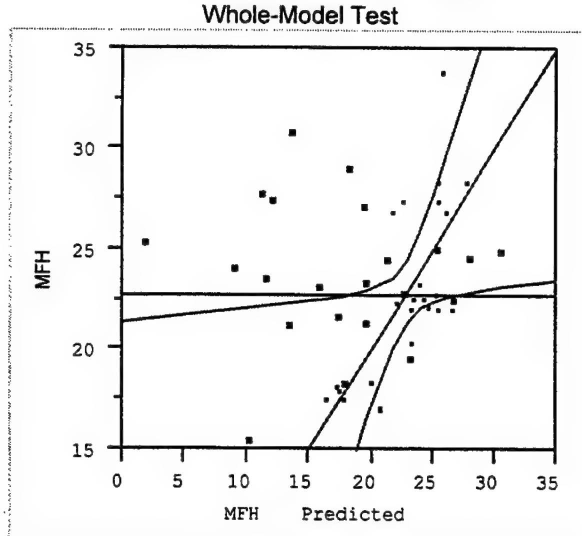
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
BRK	1	1	110.06449	8.5834	0.0094
AA	1	1	92.70868	7.2299	0.0155
POSS	1	1	81.13012	6.3269	0.0222
MC	1	1	117.43976	9.1586	0.0076
NMCM	1	1	47.22562	3.6829	0.0719
NMCS	1	1	67.60971	5.2726	0.0346

Durbin-Watson

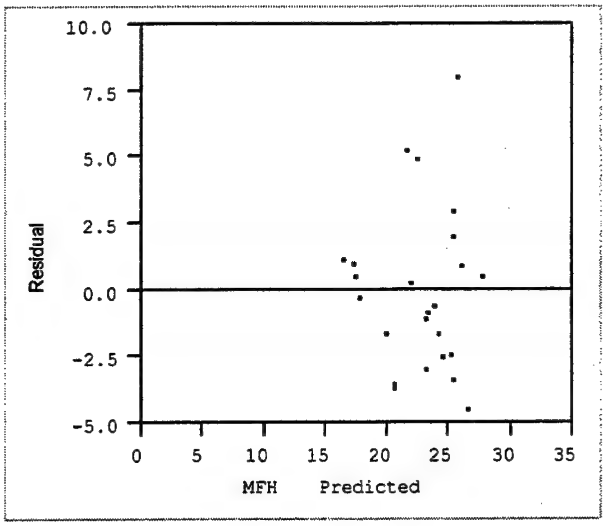
Durbin-Watson	Number of Obs.	AutoCorrelation	Prob<DW
2.4578255	24	-0.2423	0.7894

Whole-Model Test

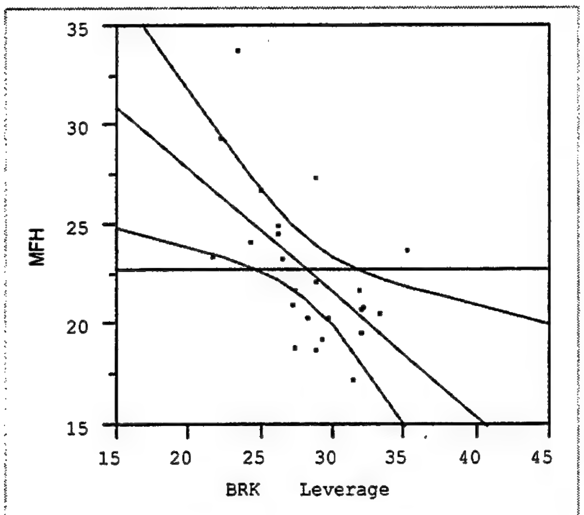


Analysis of Variance

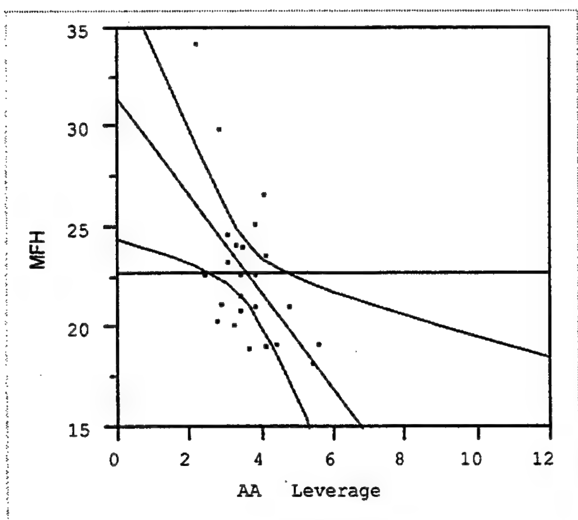
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	237.05949	39.5099	3.0812
Error	17	217.99009	12.8229	Prob>F
C Total	23	455.04958		0.0315



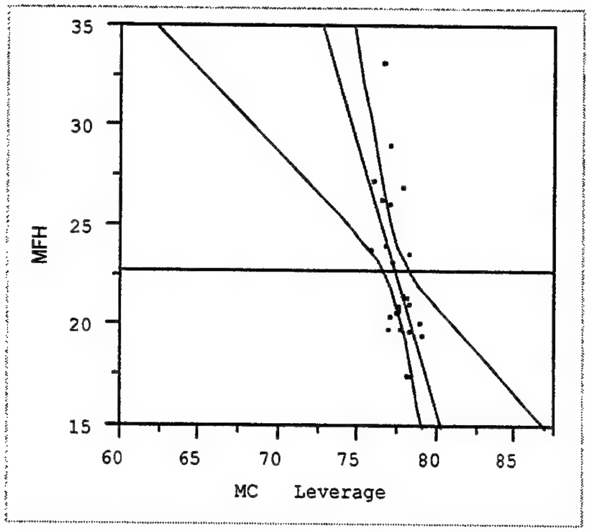
10.0
7.5
5.0
2.5
0.0
-2.5
-5.0
Residual
0
5
10
15
20
25
30
35
MFH Predicted

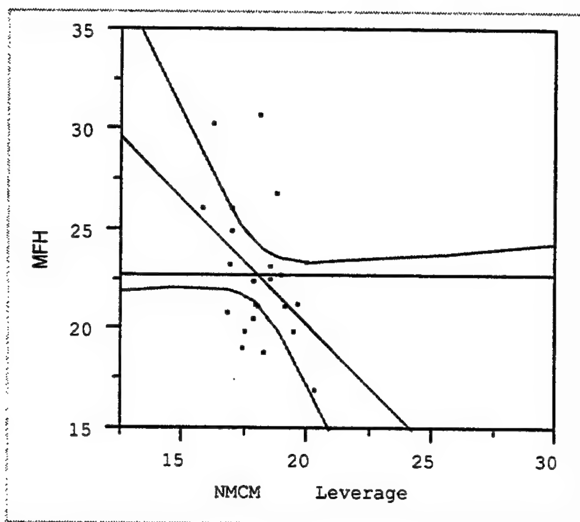


35
30
25
20
15
MFH
15
20
25
30
35
40
45
BRK Leverage



35
30
25
20
15
MFH
0
2
4
6
8
10
12
AA Leverage


35
30
25
20
15
MFH
60
65
70
75
80
85
MC Leverage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MFH
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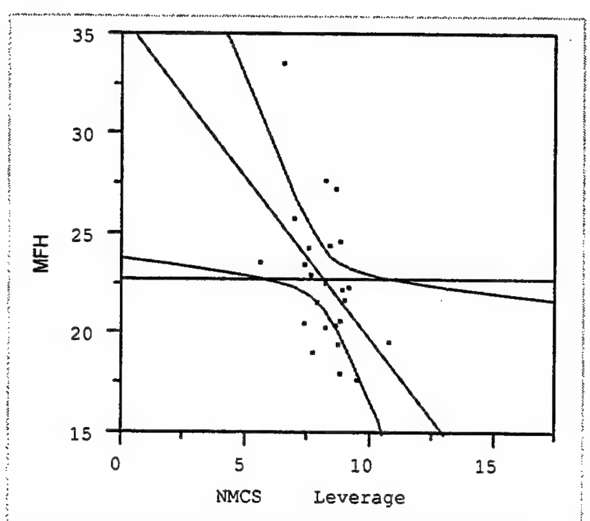
30
NMCM Leverage


35
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MFH
0
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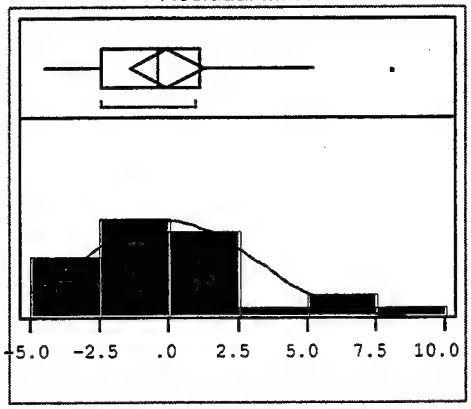
10
15
NMCS Leverage

12. Residual Analysis of the Errors for Post-Reorg MFH Model

Residual MFH



Moments

Mean	0.00000
Std Dev	3.07861
Std Error Mean	0.62842
Upper 95% Mean	1.29997
Lower 95% Mean	-1.29997
N	24.00000
Sum Weights	24.00000

Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.937646	0.1485

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Vita

Captain Larry J. Stetz was born 23 April 1969, and is a native of St. Edward, Nebraska. He attended St. Edward Public High School, where he was graduated as Valedictorian in May 1987. He attended the University of Nebraska at Lincoln, where he received a Bachelor of Science Degree in Agricultural Sciences. He received his Reserve Air Force commission on 20 December 1991. He entered active duty on 15 September 1992 at Holloman Air Force Base, New Mexico, where he served as the Assistant Officer-in-Charge of Fabrication Flight. In February 1993, he was assigned to the 7th Fighter Squadron, where he served as the Assistant Maintenance Supervisor and Sortie Generation Flight Commander, supplying aircraft for all F-117A initial pilot training. From March to July 1993, he attended the Aircraft Maintenance/Munitions Officer Course at Sheppard Air Force Base, Texas. In September 1995, Capt Stetz moved to the 552d Air Control Wing at Tinker Air Force Base, Oklahoma, where he served in various positions in the Maintenance Squadron, the Aircraft Generation Squadron, and the Component Repair Squadron, supporting E-3 Sentry operations world-wide. He completed Squadron Officers School at Maxwell Air Force Base, Alabama in April 1997. Captain Stetz entered the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio in May 1998, to pursue a graduate degree in Logistics Management. Following his graduation he will be serving as a staff officer in the Logistics Directorate at Air Mobility Command Headquarters, Scott Air Force Base, Illinois.

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13. ABSTRACT *(Maximum 200 words)*
Organizational restructuring sometimes occurs in the aircraft maintenance field, yet seldom are in-depth analyses performed after the fact to see if productivity improved. In December 1995, the 552d Air Control Wing restructured its flight line maintenance into an aircraft generation squadron concept. This study looked at before and after maintenance indicators to see if productivity improved. Maintenance data was collected from December 1993 to December 1997. Nineteen maintenance indicators were identified, and the key indicators were analyzed using means comparison and regression analysis to determine if efficiency and effectiveness had increased. The variables Mission Capable rate and Man-hours per Flying Hour were regressed to determine the prime determinants of these variables. The results indicated that the aircraft generation squadron concept did not result in a more efficient or more effective flight line maintenance organization. Efficiency and effectiveness appear to have decreased under the aircraft generation squadron concpet. The research did not determine if the old maintenance structure could have performed better than the aircraft generation squadron structure. The conclusion drawn was that the maintenance structure should be modified to increase productivity.

14. SUBJECT TERMS
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